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ROYAL COMMISSION ON COAL SUPPLIES.

SECOND REPORT

OF THE

ROYAL COMMISSION

ON

COAL SUPPLIES.

Vol. II.

MINUTES OF EVIDENCE

AND

APPENDICES.

Presented to both Houses of Parliament by Command of His Majesty.

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TABLE OF CONTENTS.

PAGE

1. List of Witnesses examined, name, description and Subject - iii

2. Scheme adopted by the Commission for dealing with the question of possible economies - - - - - - - - - vii

3. Minutes of Evidence - - - - - - - - - - 1

4. Appendices :—

I.—List of Witnesses whose evidence is contained in Vol. II. of the First Report of the Commission [Cd. 1725, 1903], with name, description, and subject on which they were examined; together with List of Appendices contained in that volume - - - - - - - - - 371

II.—Letter from the Board of Agriculture and Fisheries with reference to the possible effect of increased production upon the price of Sulphate of Ammonia - - - - - - 375

III.—Memorandum by Mr. Bennett H. Brough, Secretary of the Iron and Steel Institute, on the use of Blast Furnace Gas - 375

IV.—An Analysis of the Natural Gas at Heathfield, Sussex, by Professor H. B. Dixon and Dr. W. A. Bone - - - 377

V.—Report on the cost of running Producer Gas Plant at Messrs. Cadbury's Works, Bourneville - - - - - - 378

VI.—Briquettes - - - - - - - - - - 379

VII.—Peat - - - - - - - - - - - 381

5. Index - - - - - - - - - - - - 387

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LIST OF WITNESSES.

NAME, DESCRIPTION AND SUBJECT.

NAME.	———	No. of Questions.	Page.
ALTENHEIM, Mr. C. R. - - -	Mining Engineer, of the firm of Messrs. Edward Kochs and Co., Sheffield. *Evidence* on economies in preparing Coal for sale and use: particularly as to Coal-washing machinery and coking.	10066—10174	68
BAINBRIDGE, Mr. EMERSON - -	Consulting Engineer - - - - - - - - - *Evidence* on labour-saving machinery.	10914—11206	97
BARRETT, Mr. WILLIAM SCOTT -	Honorary Treasurer of the Mining Association of Great Britain: connected with several coal and iron companies in Lancashire. *Evidence* on economies in transport of Coal.	12071—12209	138
BEDSON, Prof. PETER PHILLIPS, M.A., D.Sc.	*Evidence* on economies in preparing Coal for sale or use: particularly as to Manufacture of Coke.	11207—11263	107
BEILBY, Mr. GEORGE T., F.I.C., A.I.C.E.	Past President of the Society of Chemical Industry, Expert Director of several large chemical works. *Evidence* on economies in the use of Coal, and on the production and use of shale oil.	9367—9631 15056—15150	29 and 269
BURSTALL, Prof. F. W., M.A., M.I.C.E., M.I.M.E., Birmingham University.	*Evidence* on the manufacture and transmission of Producer Gas.	10495—10694	79
COLQUHOUN, Mr. WILLIAM, A.M.I.C.E.	*Evidence* on economies in preparing Coal for sale and use: particularly on the Manufacture of Briquettes.	9989—10065	65
CROSSLEY, Mr. W. J. - - -	(Crossley Bros., Limited) - - - - - - - *Evidence* on economies in the use of Coal: particularly as to production of power by gas engines.	12864—12944	170
DARBY, Mr. JOHN H., M.I.C.E. -	*Evidence* on economies in preparing Coal for sale and use: more particularly coking.	8908—9183	13
DAVIES, Mr. MORGAN W., A.M.I.C.E., Swansea.	*Evidence* on waste in working in the Anthracite Coalfield, South Wales.	16040—16141	317
DEACON, Mr. MAURICE, M.I.C.E. -	Sheepbridge Coal and Iron Co. - - - - - *Evidence* on economies in the use of Coal in production of power.	14710—15055	255
DELLWIK, Mr. CARL, M.I.M.E. -	*Evidence* on economies in the use of Coal: particularly on the manufacture of Water Gas.	12945—13067	173
DES VOEUX, Dr. HAROLD A. -	Hon. Treasurer, Coal Smoke Abatement Society - - *Evidence* on economies in the use of Coal for domestic purposes: particularly on improved methods of combustion.	13243—13339	183
EELES, Mr. JOHN PROCTER - -	Colliery Sales Agent, Monmouthshire - - - - *Evidence* on economies in preparing Coal for sale and use: especially as to coke manufacture.	10175—10494	71
EVERETT, Prof. J. D., F.R.S. -	Secretary of the Underground Temperatures Committee of the British Association. *Evidence* on Underground Temperatures.	15567—15593	290
FISHER, Mr E. R. - - -	Colliery Manager, Llandebie - - - - - - *Evidence* on waste in working in the Anthracite Coalfield, South Wales.	16142—16213	321
FORGIE, Mr. JAMES TENNANT -	Civil and Mining Engineer, General Manager of and Partner in the firm of Messrs. Wm. Baird & Co., Scotland. Lately President of the Mining Institute of Scotland. *Evidence* on economies in the preparation of Coal for sale and use.	8740—8907	1

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LIST OF WITNESSES—*continued.*

NAME.	———	No. of Questions.	Page.
GOODRICH, Mr. W. F., A.I.M.E. -	London Manager of Messrs. Meldrum Bros. - - *Evidence* on economies in the use of Coal: particularly as to improved appliances for the use of inferior classes of coal and refuse as fuel.	15151—15295	272
GREENER, Mr. THOMAS Y. - -	Mining Engineer, General Manager of the Collieries of Messrs. Pease and Partners, Durham. *Evidence* on economies in preparing Coal for sale and use.	9184—9366	22
HADEN, Mr. W. NELSON, M. Inst. H. & V.E.	*Evidence* on economies in consumption of fuel for the heating of buildings by the introduction of central heating appliances.	16609—16764	343
HELBING, Mr. H. B., F.C.S. -	*Evidence* on economies in the use of Coal: particularly on the use of solidified petroleum as a substituted fuel.	14378—14465	238
HICKMAN, Sir ALFRED, M.P. -	Iron and Coal Master - - - - - - - - *Evidence* on economies in railway carriage of Coal.	11529—11910	119
HIGSON, Mr. JOHN, M.I.C.E., F.G.S.	*Evidence* on waste in working, the Limit of Depth in Mining, and economies in preparing Coal for sale and use.	9784—9988	53
HOLDEN, Mr. JAMES, M.I.C.E., M.I. Mech. E.	Locomotive Superintendent on the Great Eastern Railway. *Evidence* on economies in the use of Coal: particularly on the use of oil fuel in locomotives.	13761—14072	219
HOPKINSON, Dr. EDWARD, M.I.C.E., M.I.M.E., D.Sc., &c.	Managing Director of Messrs. Mather & Platt, Ltd. - *Evidence* on economies in the use of Coal: particularly as to the use of gas engines for generating electricity.	13068—13242	177
HUDSON, Mr JOHN, M.I.C.E., M.I. Mech. E.	A Director and Chief Engineer of Messrs. Hick, Hargreaves & Co., Bolton. *Evidence* on economies in the use of Coal: particularly as to economy consequent on improvements in steam engines.	16232—16390	326
JEANS, Mr. STEPHEN - - -	Secretary of British Iron Trade Association - - *Evidence* on economies in the use of Coal: particularly in iron and steel manufacture.	15594—15730	294
KNOWLES, Mr. JOHN - - -	Mining Engineer, General Manager of Pearson & Knowles Coal and Iron Co. *Evidence* on economies in preparing Coal for sale and use: also on economies in the use of Coal.	9740—9783	49
LEWES, Mr. VIVIAN BYAM - -	Prof. of Chemistry at the Royal Naval College, Greenwich. *Evidence* on economies in the use of Coal: particularly as to manufacture of gas for production of light.	14209—14377	232
LIVESEY, Sir GEORGE, M.I.C.E. -	Chairman of the South Metropolitan Gas Company - *Evidence* on economies in the use of Coal: especially as to the manufacture of gas for lighting purposes.	12551—12755	156
LONGRIDGE, Mr. M., M.A., M.I.C.E., M.I.M.E.	*Evidence* on economies in the use of Coal: particularly as to improvements in engines and boilers.	14652—14709	251
MCLAREN, Mr. H. - - -	Of Messrs. J. & H. McLaren, Leeds. *Evidence* on economies in the use of Coal: particularly as to possible economies in steam engines.	16391—16608	332
MACNAB., Mr. W., F.I.C. - -	*Evidence* on the utilisation of Peat as a fuel.	16765—17011	352
MILLER, Mr. GORDON WILLIAM, C.B.	Director of Navy Contracts. *Evidence* on economies in the use of Coal and on possible substitutes for it in the Royal Navy.	12211—12550	143
MITZAKIS, Mr. JOHN and THEW, Mr. H. W.	*Evidence* as to the relative cost of Coal and solidified petroleum as fuel.	14466—14485	242 241

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LIST OF WITNESSES—*continued.*

NAME.		No. of Questions.	Page.
PEARSON, Mr. RICHARD. - -	Managing Director of the Natural Gas-fields of England. *Evidence* on economies in the use of Coal : particularly as to Natural Gas as a substitute for Coal Gas.	11204—11528	110
REDWOOD, Dr. BOVERTON - -	Adviser on Petroleum to the Home Office and Consulting Adviser to the Corporation of the City of London. *Evidence* on petroleum fuel as a substitute for Coal.	13340—13607	190
RHODES, MR. F. PARKER - -	Chairman of Dalton Main Collieries, Ltd., and of Messrs. Harrison and Camm, wagon manufacturers, Secretary to the South Yorkshire Coal Owners' Association. *Evidence* on economies in the transport of Coal.	15295—15565	278
ROBERTS, Mr. JOHN, F.G.S. - -	Mining Engineer, Swansea. *Evidence* on waste in working in the Anthracite Coal-field, South Wales.	15731—16039	302
SADLER, Col. S.A. - - -	Member of Parliament and Colliery Owner, Middlesborough and Durham. *Evidence* on economies in preparing Coal for sale and use.	9632—9739	43
SEYMOUR, Mr. T. - - - - -	Manager of the Pontyberem Collieries. *Evidence* on waste in working in the Anthracite Coal-field, South Wales.	16214—16231	324
SHAW, Mr. JOSEPH - - -	Chairman of the Powell Duffryn Steam Coal Company. *Evidence* on economies in railway carriage of Coal.	11911—12070	131
STRINGER, Mr. G. E. - - -	Of Messrs. Stringer and Jagger, Park Mill and Emley Moor Collieries, Yorkshire. *Evidence* as to the advantages of Coal-cutting machines: particularly in thin seams, and as to the use of machines of the lighter types.	17012—17249	359
STROMEYER, Mr. C. E. - - -	Civil Engineer, Chief Engineer of the Manchester Steam Users' Association. *Evidence* on economies in the use of Coal : particularly in production of steam power.	12756—12863	162
THRELFALL, Mr. RICHARD, F.R.S.	Of Messrs. Albright and Wilson, formerly Professor of Physics in the University of Sydney and President of the New South Wales Royal Commission on Coal Cargoes : also manufacturer and user of Producer Gas. *Evidence* on storage and transport of Coal.	14073—14208	227
THWAITE, Mr. B. H., A.M.I.C.E., F.C.S.	*Evidence* on economies in the use of Coal : particularly as to the manufacture of Blast Furnace Gas.	14488—14651	242
URQUHART, Mr. THOMAS, M.I.C.E.	Locomotive Superintendent for many years on the Grazi and Tsaritsin Railway, Southern Russia. *Evidence* on economies in the use of Coal : particularly as to the use of oil fuel in locomotives.	13608—13760	214
WALKER, Mr. GEORGE BLAKE, M.I.C.E., M.I.M.E.	Chairman and Managing Director of the Wharncliffe Silkstone Collieries, near Barnsley. *Evidence* on economies in preparing Coal for sale or use : particularly as to German methods.	10695—10913	87

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SCHEME ADOPTED BY THE COMMISSION FOR DEALING WITH THE QUESTION OF POSSIBLE ECONOMIES.

A.—Underground.

B.—In Preparing Coal for Sale or Use.

C.—In Transport from the Colliery to the User.

D.—In Use.

A.

I.—Prevention of waste in the working place.

II.—Question of coal left in pillars.

1.—To support shafts.

2.—To support buildings.

3.—As barriers between adjacent properties.

B.

Economies in Preparing Coal for Sale or Use.

I.—Cleansing inferior kinds of Coal by washing processes and so rendering them marketable or fit for use.

II.—Manufacture of Coke.

1.—Coke ovens without utilization of gases.

2.—Coke ovens with gases utilized for heating steam boilers.

3.—Coke ovens with recovery of by-products.

4.—Processes for making coke out of coal usually considered non-coking.

III.—Manufacture of briquettes.

C.

In Transport from the Colliery to the User in the United Kingdom.

1.—Loading railway wagons and labour saving appliances at pithead.

2.—Railway carriage.

3.—Loading and unloading ships.

4.—Water carriage.

5.—Question whether it is not more economical to generate the power at the colliery and transport the power instead of the coal.

D.

Economies in Use.

I.—Production of power.

II.—Production of heat.

III.—Production of light.

I.—*Production of power.*

1. Combustion of coal in or under steam boilers.
2. a. Economies in boiler firing.
   b. „ in steam engines.
2. Combustion of gas (obtained as a by-product) for raising steam.
   (coke oven gas).
   (blast furnace gas).

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I.—*Production of Power—continued.*

3. Manufacture and use of gas for gas engines.
   a. Economies in gas making.
      Producer gas. Water gas. Mond gas. By-product gas.
   b. Economies in gas engines.
4. Possible substitutes for coal for production of power.

II.—*Production of Heat and Chemical Action.*

1. Metallurgical uses.
   a. Economies in blast furnaces.
   b. „ in steel making.

2.—Domestic use.
   a. Economies in heating dwellings.
   b. „ in cooking.

3.—Factory uses.

4.—Possible substitutes.

III.—*Production of Light.*

1.—Illuminating—gas making.

2. a. Enrichment of gas.
   b. Methods of burning—Incandescent mantles, &c.

2.—Question whether it is more economical to burn gas directly or to use it in gas engines which drive dynamos for the production of electric light.

3.—Possible substitutes (*i.e.*, Gas made from oil at the burner).

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MINUTES OF EVIDENCE

TAKEN BEFORE THE

ROYAL COMMISSION

ON

COAL SUPPLIES.

FOURTEENTH DAY.

Tuesday, 27th January 1903.

PRESENT:

The CHAIRMAN.

Sir GEORGE ARMYTAGE.	Mr. J. S. DIXON.
Sir LINDSAY WOOD.	Dr. LE NEVE FOSTER.
Mr. BELL.	Professor HULL.
Mr. BRACE.	Mr. SOPWITH.
Mr. BRIGGS.	Mr. TEALL.
Professor DIXON.	Mr. YOUNG.

The Secretary.
The Assistant Secretary.

Mr. JAMES TENNANT FORGIE, called; and Examined.

8740. (*Chairman.*) You are a civil and mining engineer with 31 years experience of all branches of mining in the Lanarkshire, Ayrshire, Stirlingshire, and Dumbartonshire coalfields of Scotland?—Yes.

8741. At present you are the general manager to Messrs. William Baird and Company's (Limited) Collieries, ironstone pits and coke works?—Yes, and a partner.

8742. Were you for three years President of the Mining Institute of Scotland?—Yes.

Mr. J. T. Forgie.

27 Jan. 1903.

8743. The statement which you have sent in, and which has been circulated to the members of the Commission will go upon the notes as it is; but there are one or two questions which I should like to put to you with regard to it?—Yes.

STATEMENT.

(1.) During my long experience I have had ample opportunity of watching and studying the economies, gradual changes, and improvements which have been taking place in the handling and preparation of coal and its products for sale and use.

(2.) My experience has principally been in the Stirlingshire and Lanarkshire districts.

(3.) The Stirlingshire Coalfield is in the Carboniferous Limestone series or Lower Coal Measures.

(4.) The Bothwell and Blantyre Coalfield is part of the great Lanarkshire Coalfield, and hitherto the outputs have mainly come from the Upper and true Coal Measures.

(5.) Little is known of the Carboniferous Limestone series in this district, but they will likely be 500 to 600 fathoms deep, and it is generally understood that coming south, the limestone bands thicken, and the coal seams thin, and lose the superior quality they have in the Stirlingshire district.

(6.) Thirty years ago the methods of handling and preparing coal for the markets and for use were very primitive and simple. With few exceptions the pits were shallow and the outputs were small, and only coals of fairly good quality and free from dirt bands were worked, and a good many pits in the vicinity of towns and villages depended wholly on cart or hill sale for taking off their outputs.

(7.) The general surface arrangements of an ordinary colliery having an output of 100 to 150 tons daily, which in Scotland was then considered a good one, were very much as I have shown on Plan No. 1.

Supplemental Plate 1.

(8.) The coal after being brought to bank was taken on a scaffold falling 1 in 80 to 1 in 100, over a weighing machine to the screen placed as near the pit mouth as possible. The hutches, having end doors, were tilted to an angle of 45deg., and discharged of the coal they

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Mr. J. T. Forgie.

27 Jan. 1903.

contained down a screen having an angle of 1 in 2 or 1 in 2·2. The screen had parallel tapered bars placed at distances apart from 1in. to 2in., according to the nature of the coal and the markets, through which the dross passed into a wagon placed on one line of railway, the coal passing over the bars into a wagon on another line of railway.

(9.) The coal in this way received no treatment except separation into two sizes, and was very much broken in the rough treatment it received in being hurled at great velocity down the screen, and with a considerable drop into the wagons. Sometimes a lad was placed in the coal wagon to pick what dirt he could, but it was little he could do in this way, and both the coal and dross therefore contained all, or nearly all, the dirt which was sent up in it by the collier.

(10.) According to the nature of the seam, the round coal was sold as house, furnace, gas, or steam coal, and the dross went to the various industries in the neighbourhood, for steam-raising or other purposes, or for making coke if the dross were of a coking nature.

(11.) Occasionally plates were laid on the top of the screen bars, and the coal and dross filled into one wagon, the mixture being in Scotland called "triping." This went largely to print, dye, and paper works, and triping from clean seams is still sold, but in smaller quantities, to these works.

(12.) The dross in many cases had a very small value, and in dull times was often unsaleable, and had to be laid in bin, owing to excessive dirt in it, and the want of local markets, the cost of transport to more distant markets being prohibitive.

(13.) It was common in Ayrshire, Fifeshire, Slamannan, and Airdrie districts to separate the small coal underground, and throw it into the waste workings. A large quantity of coal in this way has been irretrievably lost.

(14.) So much of the dross, whatever its value, and the demand for it may have been, was used to raise the steam required at the colliery.

(15.) From time to time many improvements have been adopted for the better handling of the coal, avoidance of loss, and increasing its value.

Among these may be mentioned flat plates fixed at the bottom of the screens on which the round coal was delayed in its progress to have the dirt picked out; the travelling endless plate band invented by Mr. Thos. Whitelaw, along each side of which were placed women, old men or boys to pick the dirt from the coal as it passed along; the shaking screen; and the screening of coal by means of plates perforated with round holes instead of by parallel tapered bars.

This last was a decided improvement, as it enabled the coal to be more perfectly screened, with a much less percentage of dross taken from it.

Further improvements were the even distribution of the coal on to the screen by means of conveyors and distributing jiggers, materially assisting the screening thereby. The adjustable radial end on the picking bands, to save breakage in delivering the coal into the wagon, the placing of screens and picking bands along the lines of railway instead of across them, and self-acting revolving hutch tipplers with protection plates.

There are others which I need not detail here, but modern plants in Scotland embrace now nearly all those I have mentioned.

(16.) The dross and its proper treatment came to be a matter of serious consideration at a great many collieries, threatening even their very existence. Dross from clean seams and clean workings could generally be well disposed of, but inferior qualities of dross, with an admixture of dirt, were not easily disposed of, and then at very low prices. Railway rates had to be paid on the dirt it contained, extra handling was necessary, and more of it had to be used to get the same results, and the resultant ash was heavy.

(17.) Picking dirt from the dross was impracticable, and washing was resorted to. The term washing is hardly correct, as the water is simply the medium by which the coal and dirt are separated according to their specific gravities, and this is the whole principle on which every different class of washer has been designed.

In the early washers the dross was treated in bulk such as in the trough and Robinson cone types, and while the coal may or may not have been perfectly freed from rubbish, the rubbish certainly always contained a large quantity of good coal, and the effluent water freely run off also contained a large quantity of both fine coal and rubbish in suspension, which was either run direct to the nearest stream or into settling ponds, where a pretension of purification was made. The emptying of these settling ponds frequently was a matter of great cost and discomfort.

(18.) The German method of separating the dross into various sizes and washing it by itself under conditions suitable to it, was a great improvement, and is now very generally employed. The separate sizes can either be sold separately, or where coke is made two or more of them can be mixed together again and coked.

(19.) Coal in washing absorbs a certain amount of water, and this has to be allowed for in weighing it. When used for coking the water is objectionable, and sometimes means are used to get rid of the excessive water before charging it into the ovens.

(20.) Considerable improvements have been effected in the manipulation of the coal hutches from the pit mouth to the screens, and in the return of the empty hutches, and also in the handling of all the various sizes of coal and rubbish, by the adoption, as much as is possible, of automatic and mechanical movement.

(21.) At one of our large collieries in the Lanarkshire district we quite recently razed to the ground the old pit-head screening and washing arrangements, much of which had been erected 23 years before, the rest being added from time to time. In their places we erected a modern plant, capable of dealing with a larger output more efficiently, and at less cost, and at the same time enabling us to send into the market all the various classes and sizes of coal in a much improved condition.

(22.) In making these new arrangements the time of working each day had to be considered.

Three years ago the colliers in Lanarkshire, at the call of their union leaders, reduced their working hours from 10 to 8 per day, and for several years have only worked five days a week, remaining idle every Saturday.

It was, therefore, necessary to erect plant of greater capacity to deal with the week's output in 40 hours instead of in 56 to 60 hours. This, of course, entailed very much greater capital expenditure. The plant we have erected, and which I will now briefly describe is capable of dealing with 800 tons of output in eight hours, the washer dealing with 500 tons of that. The cost has been about £14,000, and the saving in labour with an output of 550 tons a day is about 1d. per ton.

(23.) Plan No. 2 shows in a general way the course of the hutches of coal from the cages to the hutch tipplers, and the return of the empty hutch to the cage. By different falling gradients (adjusted to suit straight and curved lines of railway and the loaded and empty hutches) and mechanical creepers to recover the height lost, the hutch travels the whole circuit almost automatically, and the distance of the screens from the pit-mouth is now no consideration. *Supplement Plate 2.*

When a hutch is discharged on the tippler it stands till sent on its way by the next loaded hutch, the impact assisting to stop the loaded hutch. Rails are laid throughout of 23lbs. weight per yard, fishplated at the joints, and the switches are worked by a boy from one central position.

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Fewer hands are required by this method than by the old, and a larger output can be disposed of.

Supplement Plates 3, 4 & 5 (24.) Plans Nos. 3, 4, and 5 show the preliminary separation of coal and dross and preparation of the large coal.

Supplement Plate 6. (25.) The hutch tipplers, Plan No. 6, are so arranged that the least breakage of the coal takes place in discharging on to the distributing jigger. They are mechanically driven, and can discharge nearly three hutches per minute. The distributing jigger has a fall of 1 in 8, and its purpose is to deliver the coal in an even and continuous stream on to the shaking screen, thus ensuring absolute screening.

The shaking screen has a fall of 1 in 3½ to 1 in 3¾, according to circumstances and the nature of the coal. It has a perforated plate to let through all the small coal or dross, the round coal passing on to the travelling picking band. The perforated plates on the shaking screens with us vary from 1¼ in. to 2¼ in. diameter holes.

The travelling picking band along which the coal is now carried is endless, and composed of round parallel bars through which any small coal made in the cleaning process passes and is scraped back to the dross conveyor.

The round coal as it is carried along is cleaned and freed from all dirt and other foreign material. The coal now passes into the wagon ready for the market, the end of the picking band being radial and admitting of being lowered into the wagon so as to drop the coal as gently as possible.

At this colliery there are three such screens and picking bands placed parallel to each other for dealing with three different classes of coal—shipment, furnace, and household coal.

(26.) The dirt picked is carried on a conveyor to the pit-head, and thence by hutch to the rubbish heap. Any dirt with coal adhering to it is treated in a breaker, and mixes with the dross to be washed.

(27.) The drosses from all three screens are mixed together and conveyed to the storage hopper. The proportions of coal and dross with 1¾in. to 2in. round holes is as follows :—

Large coal - - - - -	45 per cent.
Dross - - - - - -	55 ,,

Supplement Plates 3, 4 & 5 (28.) Plans Nos. 3, 4, 5 show the arrangement for washing the small coal or dross.

From the storage hopper the dross is elevated to the separating riddle, where it is divided into six different sizes.

1. Gum through ¼in. square mesh.
2. Pearls over ¼in. square and through 7-16in. square.
3. Singles over 7-16in. square and through ⅝in. diameter.
4. Singles over ⅝in. diameter and through ¾in. diameter.
5. Doubles over ¾in. diameter and through 1⅝in. diameter.
6. Trebles over 1⅝in. diameter.

The progress of these is now entirely by gravitation till they reach the wagons prepared for the markets.

Supplement Plates 7 & 8. Nos. 1 and 2 sizes are washed in felspar washers, Plan No. 7; and Nos. 3, 4, 5, and 6 sizes in ordinary bash washers, Plan No. 8.

From the separating riddle a constant stream of coal gravitates in shoots to each of the washers. Water is circulated by a centrifugal pump into these washers, which also have pistons working in a separate chamber to agitate the coal and water. The dirt being heavier than the coal, settles to the bottom, and goes to the elevators, and is raised and drained and discharged into the wagons or rubbish heap. The coal is carried over by the water, and is drained and then sprayed with clean water to give it a bright appearance, and then drained again and passed into the trucks ready for sale.

No. 1 size, or the gum or fine coal, cannot be filled into the wagons without being specially recovered, and it goes to the gum recovery and water settler, where it is dredged out and drained, and sent to the boiler fires to raise steam for the colliery, the surplus, if any, being sold.

Nos. 2, 3, and 4 sizes are mixed and sold as washed singles.

Nos. 5 and 6 sizes are sold separately as washed doubles and trebles.

(29.) In order to prevent pollution of the rivers and loss of fine coal we have adopted the gum recovery and water settling tank in connection with the washer. The whole water from each of the washers and all the drainage and the No. 1 size of fine coal are collected and run in close pipes to the gum recovery, which is a huge tank with a dredger working in it. The water carrying fine coal enters at one end and flows very slowly to the other end, meanwhile precipitating the fine coal to the bottom of the tank, the water comparatively free from coal, but still coloured, returning to the washer again, this circulation going on all day. The dredger working against the slow flow of water, lifts the fine precipitated coal. *Supplement Plate 9.*

No water is run off during the day, but fresh water is added to spray the nuts.

After the washing is stopped at night, the water is allowed to settle for 8 to 10 hours, and the added water of the previous day is run off from the top perfectly clear into the engine pond, there to be used for the boilers.

If there are fireclay impurities in the coal a little longer time may be required for settling.

Once in a while the tank has to be discharged into a settling pond and charged with fresh water.

The water which drips from the washed coal in the wagons is drained off and passed through a small settling pond, which thoroughly clears it before it passes into the drains. These settling ponds require to be emptied very seldom.

(30.) The produce of this colliery is sold as under :—

1. Screened coal shipped to France, Egypt, Germany, Italy, and Denmark. Price 8s. 6d. at pits.

2. Screened hard coal sent to our own blast furnaces, 9s. at pits.

3. Screened household coal, all sold locally, 9s. 6d. at pits.

4. Treble nuts, sold locally and shipped to Denmark and Germany, 6s. 6d. in summer and 7s. 8d. just now at pits.

5. Double nuts, sold locally and shipped to Germany, 6s. 2d. in summer and 6s. 8d. just now at pits.

6. Single nuts, sold mostly locally, some shipped to Ireland, price 5s. to 5s. 3d. at pits.

7. Washed gum, mostly used in colliery boilers, when sold, 2s. 9d. at pits.

8. Unwashed dross, only sold when washer breaks down, 4s. at pits.

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Mr. J. T. Forgie.

27 Jan. 1903.

The following statements show the percentages of the various classes of coal and their analyses:—

BOTHWELL CASTLE 1 AND 2 PITS.

Division of Output for December, 1902.

Commodity.	Total Output.		Output Washed.		Meshes and Riddles.	
	Tons.	Per cent.	Tons.	Per cent.	Over.	Through.
					Diameter.	
Furnace Coal	542·0	4·04	—	—	1¼ ins.	—
Shipment Coal	3,442·10	25·65	—		1¾ „	—
House Coal	1,996·0	14·88	—	—	2 „	—
	5,980·10					
Treble Nuts	954·12	7·11	954·12	13·01	1¾ „	1¼ ins. and 1¾ ins.
Double Nuts	1,797·12	13·39	1,797·12	24·51	⅞ „	1¾ „ 2 „ diameter.
Single Nuts	2,801·12	20·88	2,801·12	38·20	¼ „ square	⅞ „ „
Gum	1,239·19	9·24	1,239·19	16·91	—	¼ „ square.
	6,791·55					
Rubbish:						
Ex Washers	540·4	4·03	540·4	7·37	—	1¼ ins. and 1¾ ins. 2 „ diameter.
Ex Picking Tables	105·5	·78	—	—	1¼ ins., 1¾ ins., and 2 ins. diameter.	—
	645·9					
	13,329·15	100·00	7,331·95	100·00		

Average weight of Coal in each Hutch - - 8·95 cwts.

	lbs.
Washer Dirt per Hutch of Coal	43·66
Table Dirt per Hutch of Coal	8·50
Rubbish in each Hutch of Coal	52·16

ANALYSES OF BOTHWELL COALS AND WASHED MATERIAL.

1. Analyses of Ell, Pyotshaw and Main Coal seams as sampled from face of working with visible rubbish picked out:—

	Ell Coal.	Pyotshaw Coal.	Main Coal.
Volatile matter, &c.	33·70	33·60	31·85
Fixed carbon	51·70	52·95	53·95
Ash	5·00	6·10	3·60
Water	7·60	6·60	10·00
Sulphur	2·00	0·75	0·60
	100·00	100·00	100·00
Phosphorus	0·008	0·018	0·007

2. Analyses of mixed unwashed dross from the output of the above three seams:—

Volatile matter	30·40
Fixed carbon	43·10
Ash	18·20
Water	8·30
	100·00

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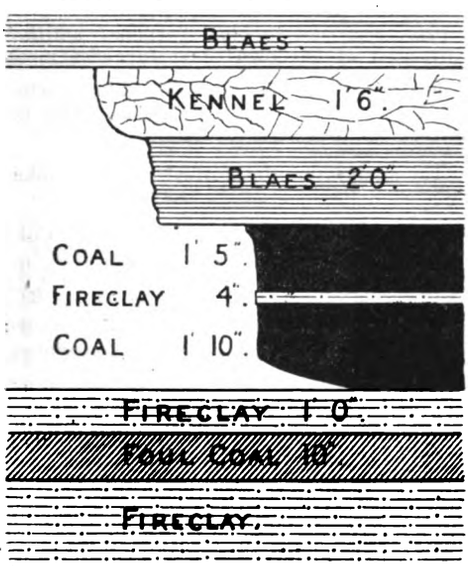
3. Analyses of the classified dross after being washed :—

	Washed Gum.	Washed Single Nuts.	Washed Double Nuts.	Washed Treble Nuts.	Rubbish from Felspar, Two Washers.	Rubbish from Bash, Four Washers.
Volatile matter - - -	33·50	34·80	33·50	34·00	20·80	14·90
Fixed carbon - - -	51·90	51·70	51·60	52·00	10·20	10·90
Ash - - - - - -	6·50	4·10	5·10	6·00	64·80	72·30
Water - - - - -	8·10	9·40	9·80	8·00	4·20	1·90
	100·00	100·00	100·00	100·00	100·00	100·00

The seams from which this coal is produced are the Ell, Pyotshaw, and Main of the Upper Coal Measures.

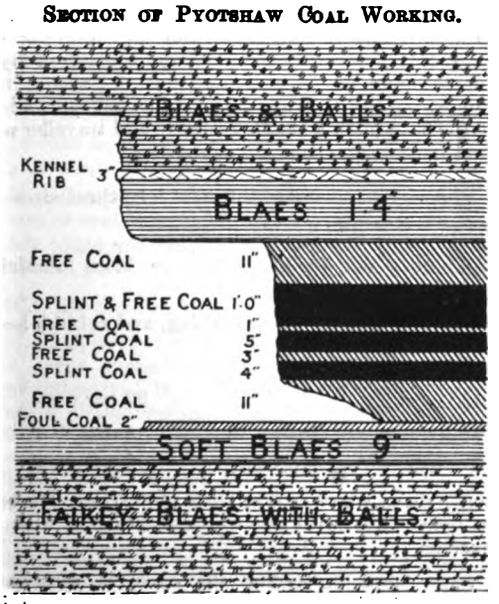
The Ell in this district is split up by bands of dirt, and contains pyrites. The method of working is long-wall, and a large quantity of dirt is sent up with the coal.

SECTION OF ELL COAL WORKING.

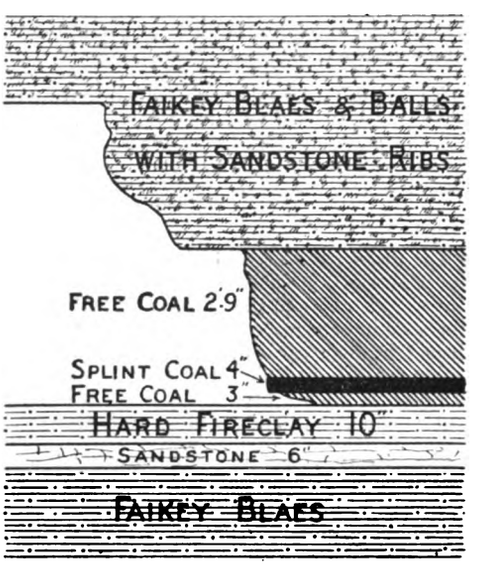


The Pyotshaw and Main Coal seams are not split up, but the nature of the roof and pavement and working tend to dirt being filled with the coal unless the collier is careful.

SECTION OF PYOTSHAW COAL WORKING.



SECTION OF MAIN COAL WORKING.



(31.) The dirt picked from the large coal and washed from the dross amounts to 50 lbs. to 80 lbs per hutch of coal weighing 9½ cwts., and this weight is added to the tare, our arrangement with the collier being to pay for clean coal only, so long as we can give the checkweighman ample opportunity for ascertaining the weight of the dirt.

This dirt in the coal has in this district been a vexed question for a long time, and has led to many disputes, and I regret to state we do not get the assistance from the colliers and their union we should in keeping the coal clean. In many cases the coal could be kept very much freer of dirt underground than it is, and the eight hours day has much aggravated the matter, as in his hurry to complete his day's work in eight hours the collier does not devote the time necessary to properly pick the dirt from the coal. The clauses of the Coal Mines Regulation Act, 1887, bearing on the question are not framed in such a way as to give any material assistance. On the contrary, they have led to misunderstandings and disputes.

At our four Bothwell collieries the output runs about 55,000 tons of coal per month, and the dirt we pick and wash from the coal amounts to about 4,000 tons. This rubbish has to be hauled long distances underground. drawn up the shaft, handled on the pithead and in the screening and washing plant, and afterwards disposed of, covering valuable land.

It will be seen that this means a very large expenditure on unproductive material, much of which might be saved by more care being taken by the miner at the coal face.

(32.) But for the improved screening, picking and washing arrangements adopted, these seams in many cases could not be worked to a profit except when times were good and the demand such that the quality was not so carefully investigated, and many seams at one time

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Mr. J. T. Forgie.

27 Jan. 1903.

considered unworkable owing to being split up by bands of dirt will in the future, as the better class seams become exhausted, have their opportunity.

During the past few years several old abandoned collieries have been restarted and improved plant erected at them and such seams opened up.

The saving by the adoption of such methods and machinery as I have described is not as a rule shown in any reduction in the cost per ton (often an increase is shown), but in the great increase in value of the coal so treated, and in the prevention of loss of a large quantity of coal.

We now practically recover and make use of almost all the coal put out, and the rubbish we take from the coal has been tested and found to contain not more than from 1 to 2 per cent. of free coal.

(33.) At current prices for all classes of material, we realise an average of about 6s. 10d. per ton. If we sold as coal and unwashed dross we would realise a little over 6s. 1d.

(34.) At our Kilsyth works, where we work the seams of the Lower Coal Measures, we have two qualities, coking coal and anthracite coal.

The pits having comparatively small outputs have those separated into coal and dross only, the coal going direct to the markets, the dross going to two or three central washing plants.

(35.) Coking Coal.—The round coal is cleaned on picking bands at the pits.

(36.) The dross from several pits is washed at central washing plants situated at the coking ovens. These plants are very similar to that I have already described, but after washing the various sizes of coal are collected and crushed in disintegrators and elevated into a large storage hopper, from which the coal is drawn to be charged into the coking ovens. Coal so crushed into a fine powdery condition makes a more uniform coke.

Supplement Plate 10.

(37.) Plan No. 10 shows the arrangement for washing, crushing, storing, and preparing the coal for coking. Besides acting as a store, the large hopper gives the washed coal opportunity to drain off part of the moisture added to it in washing, which moisture is injurious to the coking and also to the hot brickwork of the ovens.

(38.) There have been several methods of coking coal in the past. Coal without any treatment used to be coked in large masses between bricks walls, with and without treatment in rectangular and circular Beehive ovens, and now in the numerous types of patent retort ovens with and without bye-product extraction plant.

In Wales the rectangular oven seems to meet with most favour. In Durham and Scotland the circular Beehive oven is the prevalent one, while in Germany, Belgium, and other parts of the Continent coking is done nearly wholly in patent retort ovens. These are being introduced gradually into this country. In America the coke is wholly made in Beehive ovens.

Supplement Plate 11.

(39.) Plan No. 11 illustrates the Beehive ovens we have recently built. They are charged with coal from the top by bogies, and the coke, after being cooled by water, is drawn by long forks and filled with grapes into the wagons. The watering inside of the oven, unless very carefully done, is very injurious to the brick lining.

The coking process takes from 84 to 96 hours for each charge of 7 tons of coal, and there is very great waste of coal through combustion caused by the admission of air to the oven. The gases from the coal burn inside the oven and generate the heat to coke the coal, and in former times the burned gases or waste heat found vent to the atmosphere through the charging hole. This was a loss of heat and a public nuisance. The ovens were afterwards built back to back with a flue between, and the waste heat was conducted to a chimney. This reduced the nuisance.

(40.) Now the waste heat is conducted to boilers to raise steam.

We have 215 Beehive ovens, 11ft. diameter, the gases from which are conducted underneath 12 boilers, and steam is raised to wash and crush all the coal, and do all the work connected with these ovens, and in addition steam is conducted 200 yards to a colliery and does all the necessary work there. The boilers at this colliery were taken away several years ago, and now it depends entirely on steam supplied by the coke ovens' boilers.

The utilisation of the waste heat in this instance effected a monthly saving of from 600 to 700 tons of the best triping.

The more regular heat obtained by this method ensured a better supply of steam, and we have no trouble with boiler repairs such as were necessitated by the hand-firing process.

(41.) The best coking coal of the district is used to make the best foundry coke in these ovens. Seven tons of coal yield fully 4 tons of coke. The coke is 2ft. 6in. to 3ft. in length, and has a beautiful silvery lustre.

(42.) Ironfounders and others have a decided preference for Beehive coke to that made in patent ovens, although made from the same coal, and this has caused delay in the adoption in this country of the latter to any great extent.

(43.) The coke is divided into—

(1) Large coke, wholly sent to foundries, engineering works, etc., all over Scotland. Price 21s. at ovens.

(2) Coke nuts, sent to blast furnaces, smiths' fires, etc. ; all used at our own blast furnaces meantime.

(3) Coke dust, so mixed with ash and brick, etc., as to be unsaleable, and sent to rubbish heap. This is 4 to 5 per cent. of the total.

(44.) The analyses of the washed coal and coke are as follow :—

	Coal.	Coke.
Volatile matter - - -	27·20	0·50
Fixed carbon - - - -	54·23	89·30
Ash - - - - -	5·00	8·00
Water - - - - -	13·00	1·50
Sulphur - - - - -	0·57	0·70
	100·00	100·00
Phosphorus - - - -		0·015

(45.) Our second class coking coals are coked in the patent retort ovens along with an admixture of the best coking coal. The type of oven used is the Semet-Solvay, and the gases have the bye products extracted. There are four batteries of 25 ovens each placed in two parallel rows. Plan No. 12 gives an idea of the construction of these ovens. *Supplement Plate 12.*

These ovens are charged by three charging holes from the top with 4 tons of coal each, and the coking of the coal takes 24 hours, the coke being discharged by a steam-driven ram on to a sloping hearth, where it is cooled by water and then passed on to a conveyor, which delivers the coke on to a shaking screen, and traveller with radial end to save breakage.

(46.) The screen separates the coke into three sizes—

(1) Large coke, sold for blast furnaces.

(2) Coke nuts, sold for blast furnaces, brass foundries, and smith's fires.

(3) Coke dust, sold for brick-making, and rubbish heap.

The percentages are :—

Large coke - - - - -	92 per cent.
Coke nuts - - - - -	4 per cent.
Coke dust - - - - -	4 per cent.

The coke dust, which is free from impurities, has been tried in boiler fires with forced draught, but with no great success.

The water used in cooling the coke is afterwards settled and purified in a coke dust recovery tank similar to that described in the coal washing plant, and run off to the streams. The wet coke dust recovered is sent to the rubbish heap.

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Supplement Plate 13.

(47.) Plan No. 13 shows the general arrangement of the coke ovens and the bye-product plant, and the circulation and method of treatment of the gases.

The gases are drawn from ovens by rotary exhausters of the Waller and Laidlaw type, into a hydraulic main, then through tar washers and condensers, being coolod below 80 degrees Fahr., and then forced through water and creosote oil scrubbers, yielding up their tar, ammonia, benzole, and, if wanted, cyanogen.

The stripped gases are then conducted back to the ovens and mixed with air, which is heated to 500 degrees or 600 degrees Fahr., by being passed through the under brick structure of the ovens, and the mixture of gas and air is then kindled and passed along the horizontal side and bottom flues of the ovens to heat and coke the coal.

The waste heat is carried under 12 boilers to raise steam for the whole plant, and then passes up the chimney.

(48.) The ammoniacal liquor is distilled and manufactured into sulphate of ammonia, the fixed ammonia being recovered by adding lime.

(49.) The tar is dehydrated and sold as such, or is further distilled and manufactured into creosote oil, naphthaline, and pitch. Any ammoniacal liquor and light benzole given off in the distillation of the tar are sent to the liquor tank and the benzole plant to be there treated.

(50.) The crude benzole is sold as such, or is rectified, yielding gas enriching 90 per cent. benzole, ordinary 90 per cent. benzole, 50 to 90 per cent. benzole, and solvent naphtha.

(51.) Cyanogen is not recovered, the price not being tempting.

(52.) The coal as it is charged into the ovens contains 12 to 15 per cent. of moisture, and is consequently very injurious to the lining of the ovens, which have to be renewed every two years at a cost of £30 to £50 an oven, with numerous and constant repairs between times.

(53.) The analyses of the coal as charged into the ovens and the coke made therefrom are as under:—

	Coal.	Coke.
Volatile matters - - -	29.87	1.50
Fixed carbon - - -	51.48	86.70
Ash - - - - -	4.92	8.00
Water - - - -	13.00	3.00
Sulphur - - - -	0.73	0.80
	100.00	100.00
Phosphorus - - -		0.014

(54.) The large coke is sold to blast furnaces in Scotland and Cumberland and for malting purposes, the price at ovens being 12s. 9d. to 13s. 6d.

The coke nuts go to blast furnaces, smiths' fires, etc., locally, the price at ovens being 11s. to 12s. per ton.

The coke dust sold goes to brick-works, and the price is 1s. a ton.

(55.) The patent retort ovens give a larger yield of coke per ton of coal than the Beehive oven, and the 100 ovens at this plant are capable of producing 300 tons of coke per day.

(56.) The yield of bye-products is very variable.

(57.) Sulphate of ammonia is principally used as a fertiliser, large quantities being used, particularly in the sugar industry. It is also the chief source for the preparation of liquor-ammonia and other salts of ammonia used in commerce, and of anhydrous ammonia for refrigerating machines. The markets are France, Belgium, Holland, Italy, Spain, East and West Indies, and the United States. The price is £11 to £11 5s. per ton at the ovens.

(58.) Tar is used in the dehydrated condition for the manufacture of roofing felt and other waterproof materials, and also as a crude paint. It is, however, mostly distilled. The markets are India, Germany, Norway, Sweden, and Russia, and the price about 1½d. to 2d. per gallon at the ovens.

(59.) Pitch is mainly used for the manufacture of briquettes, in which it acts as a cementing material. It is also used for jointing in paving work, and in making smooth pavements in conjunction with sand and gravel or stones. The markets are France, Germany, Belgium, Spain, Italy, United States, and Canada, the price being lately very high—50s. to 52s. per ton at the ovens.

Mr. J. T. Forgie.

27 Jan. 1903.

(60.) Creosote oil is used principally for timber preservation. The markets are France, Germany, Sweden, Spain, Portugal, United States, and Canada, the price at the ovens being about 1½d. per gallon.

(61.) Naphthaline is used in colour making and for sanitary purposes, but is difficult to dispose of. The markets are France, Germany, Belgium, and United States, the price at ovens being 20s. per ton.

(62.) Benzole 90 per cent. is now largely used for the enrichment of coal gas. It is, with 50 per cent. benzole, the basis of the series of aniline colours for which there is a large demand. The markets are the local gas works, France and Germany. Prices are for 90 per cent. 7d., and for 50 to 90 per cent. 6d. to 6½d. per gallon at the ovens.

(63.) Solvent naphtha is used for colour and dye making, but its chief use is, as its name implies, as a solvent for india-rubber in the manufacture of waterproof fabrics. The market is France, and the price 8d. per gallon at the ovens.

(64.) The prices of all these bye-products are very fluctuating, and it is seldom, if ever, that they are all profitable at one time.

The whole plant is a very expensive one, both in capital expenditure and in running repairs and renewals, and it could only be warranted in a coalfield where a constant and plentiful supply of coal of a fairly good coking quality could be commanded. The works must be kept going night and day, including Sundays, and labour has to be paid for at a higher rate in consequence.

(65.) Owing to the narrowness of these ovens, and the coking taking place from both sides, and meeting in the middle, the coke made in patent ovens has not the long shape and size of Beehive oven coke, neither has it the same silvery appearance.

There is little difference, if any, in the quality, as has now been substantially proved by tests in blast furnaces over a considerable period. Although smaller in size, the patent oven coke is uniform, and quite hard enough to stand the burden and pressure in high blast furnaces. Iron founders have their prejudice against it, but in time this prejudice will be overcome, particularly when a larger proportion of the coke in the country comes to be made in patent ovens.

(66.) The recovery of the bye-products does not, I think, affect the quality of the coke made in patent ovens.

(67.) Poorer class coking coals may coke better in these ovens by being compressed in bulk before being charged into the oven, and there is now good reliable machinery made for this purpose.

(68) Anthracite Coal.—The output is passed over shaking screens with holes large in diameter, sometimes 3 in. diameter, the round coal passing into a wagon.

The dross is separated into

a. Gum.

b. Single nuts.

c. Double nuts.

d. Treble nuts.

e. Jumbo nuts.

b and c sizes are washed in a small washer of similar type to that I have already described. The round coal when it cannot be sold as such is broken by special machinery to prevent disintegration and separated into the same various sizes as the dross.

The fine gum is mostly used in the colliery boiler fires mixed with gum of more bituminous nature, and in some cases forced draught is used. In this way all our fine and inferior fuel is used at our own works, leaving the better qualities to be sold.

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Mr. J. T. Forgie.

27 Jan. 1903.

(69.) The analysis of the anthracite coal is as follows:—

Volatile matters	6.50
Fixed carbon	86.50
Ash	4.00
Water	2.30
Sulphur	0.70
	100.00
Phosphorus	0.014

(70.) The round coal is sold locally for bakeries and in Ireland for burning lime, and the price is 12s. 6d. per ton at pits.

The Jumbo, treble, and double nuts are sold locally, and to Denmark, France, Germany, and Holland, and the prices are 14s. to 15s. per ton.

The single nuts are sold locally for steam raising purposes, the price being 7s. per ton at pits.

(71.) Some of this coal has recently been exported to America, but as this demand is solely due to the recent American coal strike, it is only temporary.

(72.) But for the coking and anthracitic properties of these seams some of them could not be worked to a profit, as the depth and cost of sinking and working is high, and the seams, with one or two exceptions, are thin, some of them being divided by bands of stone.

It is difficult to say what causes the coal seams in this district to be of a coking nature.

The strata are very much intersected and intruded into by thick whinstones, which destroy the coking qualities of the coal seams near to them, and make them anthracitic. Where they are neither coking nor anthracitic, but in the intermediate stage, they cannot be worked at present, as while the round coal might be sold as steam coal, the dross would be of little value. In this condition the coal is usually very soft, and makes a large percentage of dross. The fixed carbon varies from 70 to 84 per cent.

When the volatile matters rise to above 7 and 8 per cent. the coal gets too soft for anthracite, and the working has to be abandoned.

In the future these seams may be workable when the coal can be utilised to better purpose than it can be at present.

(73.) In this district, as in many other parts of Scotland, there are several seams of fair thickness, but so poor in quality that they are at present unworkable. Some seams also have inferior bands of coal, which are so inferior and high in ash as to be unsaleable, and these have to be left underground.

The Hirst or Shirva coal of the Lower Coal Measures is an instance of the former, and the Ell coal of the Upper Coal Measures in a large part of Lanarkshire is an example of the latter.

(74.) In a producer plant like the Mond or Duff, with Ammonia Recovery, these seams might be utilised and a price paid to the coalowner which would yield a profit, if the transport charges were not high and the gas generated could be used for various purposes, such as driving gas engines or raising steam for electric plant, etc. These classes of plants are as yet in their infancy, and would probably only pay if erected on a large scale.

(75.) Briquettes are frequently made from dross, for which a ready local market at profitable prices cannot be found, but the dross must be of good quality, and the ash after washing be low and of a heavy nature, especially if the briquettes are to be used for household purposes.

Our firm in Ayrshire treat the dross of a certain district in this way, and make an excellent briquette, which is sold for household use all over Scotland. The dross is washed in a Robinson washer in bulk, and mixed with from 9 to 10 per cent. of blast furnace pitch. The mixture is then disintegrated and made into briquettes in the usual types of machines under great pressure. These briquettes are 4in. by 4in. by 3½in. in dimension, and weigh 4½ lbs. each. The ash in the washed dross is from 4 to 5 per cent., and in the pitch about 7 per cent., and in the briquette 5·3 per cent.

About 15,000 to 16,000 tons per annum are made at these works, and I think there are only other two such works in Scotland, and the whole annual make of briquettes in Scotland will not exceed, if it reaches, 45,000 tons.

They cannot be used in blast furnaces, as the pitch seems to burn early away, leaving the fine coal as dust, which is liable to choke the furnace. They can be used in locomotives, and on the Continent, in France and Spain especially, large quantities of briquettes are made, and Welsh briquettes imported, for locomotive use.

The coke dust and fine anthracite coal has been experimented with, but without encouraging results so far.

The cost of making briquettes, exclusive of the value of the dross and the pitch, which vary considerably, but including wages, furnishings, and fixed charges, ranges from 1s. 8d. to 2s. 6d. per ton.

Eleven shillings to 11s. 6d. a ton is realised for the briquettes now, but in summer the demand slackens and the price falls, and quantities are stocked.

The demand at present for briquettes in Scotland seems to be limited to house purposes, and only a freely burning dross with a low percentage of ash of a brown colour and heavy specific gravity can be used in their manufacture.

(76.) I have described the various methods of treating coal of all sizes and qualities in the districts I am acquainted with, and am of opinion that by the adoption of one or more or all of them according to circumstances, together with further new improvements as they evolve, it will be possible in the future to work many seams of coal, poor in quality and divided by bands of stone, which were at one time thought to be unworkable to profit.

(77.) The adoption of such intricate and extensive plant, which cannot very well be put up on a small scale, entails a very large capital expenditure, and to warrant this expenditure the mineral leaseholds must be more extensive, and possibly of longer duration. Hitherto a large number of the leaseholds in Scotland have been comparatively small, but with the necessity for deeper sinkings and the erection of expensive modern plant, the tendency has been of late to increase the size of the holdings and to work a larger area from one colliery. The results of this action will be greater economies, and better preparation of the coal and its products for the markets.

(78.) The collier can also do his part to make the working of the poorer seams an economical possibility. At present he does not recognise his responsibility in this matter, and I regret to have to state that he sometimes sends up his produce in such a condition as to make it almost impossible to prepare it for the market, no matter what means are applied.

The great bulk of the foreign material he sends up along with his coal could in most cases, with the application of a little more care and time on his part, be separated and left underground where there is as a rule plenty of room for it, and thus a vast unnecessary expense in haulage underground and surface handling and the covering of valuable land could be avoided.

(79.) This foreign material, together with other stone from the pits, can be, and is in some instances, made into bricks, but in our case, as in many others, it is unsuitable for this purpose

(80.) So far as I can judge, any great further improvements in the handling and preparation of coal must follow in the wake of further improvements in methods of using and consuming coal.

As time goes on much more of the inherent value of coal will be taken from it, and the methods of preparation of the coal may have to be changed and improved to suit the different conditions under which coal may be used in the future.

8744. (*Chairman.*) After setting out particulars with regard to the arrangements for getting coal, etc., and describing the progress that has been made with regard to screening, and such like, I gather that in your view the modern plants in Scotland embrace practically all the improvements which have been made available?—That is so.

8745. You would say now that the practice as regards screening the coal, and so on, both from the economical

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and effective point of view, is well up to date?—That is so.

8746. I gather you have no suggestion to make on that point with a view to improving the present practice?—I think we are about as far as we can go at the present time.

8747. In your proof you speak of the process of washing the coal, and I gather that the German method which you refer to is, in your opinion, a great improvement upon the methods previously adopted, and that that method is now very generally employed?—That is so.

8748. When you speak of the German method, do you refer to the inventions of some German firms, or to the practice which is adopted in Germany generally?—I think at first it was the invention and the design of the Germans specially; but for a great number of years, through necessity, the German coal masters have been adopting that class of machinery for washing and cleaning coal.

8749. I gather from what you say that the German coal is smaller, and, as you now put it, the necessity was so great as to lead them to adopt those measures?—Yes, and I think they are working seams which are considerably inferior to those which have been worked in this country in the past.

8750. As the result of using this method of washing they make a higher price for their product relatively than we do?—Yes, they increase its value.

8751. To afford to put down a modern plant complete involves a larger area of coal to be worked, and a larger output, does it not?—Yes.

8752. That is the tendency?—The expenditure being greater, the coal master is inclined to have a larger area to work.

8753. Then you go on to speak of what you call the drosses, and you say that the proportion of coal and dross with one and a quarter to two inch round holes gives 45 per cent. large coal and 55 per cent. of dross?—Yes.

8754. In the term "dross" I gather you include the small coal?—It means the small coal that passes through the one and a quarter inch and two-inch diameter screens.

8755. It would also include any dirt?—Yes.

8756. Then really these figures of 45 and 55 per cent. respectively may be taken to be the product as it comes to the surface?—Yes, that is so.

8757. (*Sir George Armytage.*) Do we understand the 45 per cent. is 45 per cent. of the whole that comes to the surface?—45 per cent. of the whole that comes to the surface. Take the first three figures that I give in the Table which sets out the division of output for December, 1902, of the Bothwell Castle pits: Furnace coal, 4·04 per cent.; shipment coal, 25·65 per cent.; house coal, 14·88 per cent.—it comes very nearly to the 45 per cent.

8758. (*Chairman.*) I want to ask you a question about the figures that you give at the bottom of that table. You speak of the average weight of the coal in each hutch as being 8·95 cwts. You then give the number of pounds per hutch of washer dirt as being 43·66 lbs., and table dirt per hutch of coal 8·50 lbs., making a total of rubbish in each hutch of 52·16 lbs. That works out at how much?—It is about 5½ per cent. of the whole output.

8759. Then you say that the dirt picked from the large coal and washed from the dross amounts to 50 lbs. to 80 lbs. per hutch of coal weighing 9½ cwts.?—Yes. I should explain here that the first part only refers to one colliery, and the other part refers generally to the whole of our collieries. We have it as high sometimes as 86 lbs. per hutch. The weight of the hutch varies a little at the different collieries.

8760. That is a little over 6 per cent.?—Yes, about 6 to 8 per cent.

8761. Then a little later on you say, "At our four Bothwell collieries the output runs about 55,000 tons of coal per month, and the dirt we pick and wash from the coal amounts to about 4,000 tons." That is about 7 per cent.?—About 7 per cent.

8762. They seem to be all there or thereabouts?—Yes, they are all very much the same.

8763. Then you go on to speak of the coking and the coking ovens. You say, speaking of the boilers at a particular colliery: "The boilers at this colliery were taken away several years ago, and now it depends entirely on steam supplied by the coke ovens' boilers. The utilisation of the waste heat in this instance effected a monthly saving of from 600 to 700 tons of the best triping." What does that mean?—That means large and small coal mixed together. *Mr. J. T. Forgie.* 27 Jan. 1903.

8764. When you speak of a monthly saving of from 600 to 700 tons, on what quantity was that saving effected? As I understand this is a saving owing to the use of the waste heat from the ovens for raising steam compared with firing the boilers formerly by coal in the ordinary way?—Yes.

8765. How do you, therefore, put the saving? What was the total quantity used for such purposes previously on which this saving of 600 to 700 tons monthly was effected?—I should explain this a little. The colliery at which this saving was effected was a colliery producing at that time about 6,000 to 7,000 tons a month. We were using about 10 per cent. in boiler fires. Of course, the ovens from which the heat comes to raise the steam, or from which the steam comes to raise that coal, receive the coal for coking from a number of collieries, and not from this colliery alone. We have 215 ovens, and that composes the coking plant for the district in which we have a great many collieries. So that the steam was not supplied by the coke made from the coal produced at this colliery alone.

8766. In fact, what you say is this—that whereas you formerly used at that colliery 600 or 700 tons a month for the purpose of raising steam, you now utilise the waste heat in the ovens and thereby save the whole of that coal?—That is so.

8767. Then you go on to speak of the best coking coal and the district making the best foundry coke in these ovens, and these are the Beehive ovens, as I understand?—Yes, the ordinary size, 11ft. in diameter.

8768. You say 7 tons of coal yield fully 4 tons of coke?—That is so.

8769. May we take it that in the district of which you speak, and of the coal of that district, that that would represent about the yield generally?—Yes, through that district.

8770. That is to say, there is nothing special in these figures to this particular coal or colliery?—No; while, of course, there are some collieries about us in which it takes a little more coal—it is a little leaner—but, generally speaking, in our district that is about the figure.

8771. Then you say that ironfounders and others have a decided preference for Beehive coke to that made in patent ovens, although made from the same coal. Is that because it is tougher or harder?—It is larger. It stands the burden in the cupola better.

8772. Then you speak of a type of oven used, the Semet-Solvay; is that what you call one of the patent ovens?—Yes.

8773. Does that give good results?—Yes, excellent results.

8774. Is it used to a considerable extent in Scotland?—No; we are the only people who have used this kind of oven. There are a few Coppée ovens in Scotland, and a few Bauer ovens, but, with the exception of these, all the others in Scotland are Beehives.

8775. Is there any reason why they are not extended if they give good results?—In Scotland, so far, there has not been very much good coking coal worked; and where it has been worked it has been worked on a very small scale. A plant of this kind requires a large initial capital expenditure, and probably that has prevented it being adopted where otherwise it might have been.

8776. What is the output with a plant of this description?—300 tons of coke per day, large and small.

8777. And that on the basis of 7 tons of coal to 4 tons of coke?—No, it takes much less coal in the patent ovens.

8778. By the patent oven you get a larger quantity of coke from a ton of coal?—We do. We get about 3 tons of coke from about 4 tons of coal, or a little over,

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Mr. J. T. Forgie.

27 Jan. 1903.

as against 4 tons of coke with nearly 7 tons of coal in the Beehive. If I may put it in this way, in the Beehive ovens we take about 33cwt. of coal to make a ton of coke, and in the patent ovens we take about 27 to 27½ cwt.—between 27 and 28 cwt.—of the same coal.

8779. Does this apply to the same system? You say the patent retort ovens give a larger yield of coke per ton of coal than the Beehive oven, and the 100 ovens at this plant are capable of producing 300 tons of coke per day?—Yes, that is so.

8780. That is really the summing up of the case for it?—Yes.

8781. Then you refer to the poorer class of coking coal, and I gather that you find the poorer class of coking coals are improved by compressing?—Yes; I have not much experience of compressing. I have seen it done, and it is my opinion that the poorer class of coking coal would be improved by compressing.

8782. Does compressing tend to make the coke better or to produce a larger quantity?—I do not think it increases the quantity of coke made from a certain quantity of coal, but it improves the quality of the coke made.

8783. Then you go on to speak about briquettes. Are there many briquettes made in Scotland?—I think I mentioned that there are only about 45,000 tons per year made in Scotland, and they are nearly all used for domestic purposes—I might say wholly used for domestic purposes.

8784. They are made from the dross?—Yes, and from very good bituminous seams—good quality coal.

8785. Have you any experience of the poorer quality of coals being made into briquettes?—They have never made them in Scotland from poor quality coal, so that I have no experience.

8786. You think it is rather the good quality of the coal that facilitates the use for domestic purposes in that form?—Yes. The value of the briquettes is very considerably reduced by the quantity of pitch that is put into them. The ash must be necessarily kept low for a briquette. There is a large field, I think I may say, for briquette making in Scotland, probably from the small coals, and from some of those which are high in fixed carbon—coals probably with from 75 to 84 per cent. of fixed carbon. These coals in this district will not coke; they are too low in volatile matter and too high in fixed carbon. Usually in that condition they are very soft, and make a very large proportion of dross. At the present time the large coal could be sold as steam coal, but there is no market for the dross at a profitable price.

8787. What do they do with it now?—It is left unworked.

8788. The seam is not worked?—It is not worked.

8789. (*Professor Hull.*) What is the limit of the thickness of such a seam as you are describing now, which is left?—Well, we have them from 2ft. up to 2ft. 9in. and 3ft. thick.

8790. (*Chairman.*) They are left not on account of the thinness of the seam only, but on account of the quality of the coal?—That is so. The large coal is very suitable for steam coal purposes.

8791. (*Professor Hull.*) Are they in the carboniferous limestone series?—The series there is very much affected by intrusive whinstone, varying from 10 to 40 fathoms thick, and the coals when they come within a certain distance below, to about the depth below the whinstone that the whinstone is thick, become anthracite coals. As they get gradually further from the whinstone they become steam coal, and then get into coking coal.

8792. (*Chairman.*) Are there any briquettes shipped?—Not from Scotland.

8793. There would be no difficulty about shipping them if they could be made as you suggest?—I think they would develop the shipping market if made.

8794. Do you know whether, if the briquettes were made from the small coal of the same seam as this coal which you describe as being good steam coal, they would be available for steam purposes?—Well, in some cases I think they might be. They would not do in blast furnaces, for instance. They would be available for locomotive boilers or stationary boilers.

8795. Is the tendency to make more smoke with briquettes than with large coal?—I should think the pitch tends to a little more smoke being made.

8796. You have prepared some very interesting plans, and I think I ought to give you the opportunity of explaining to the Commissioners any points in connection with them.—(*The Witness explained the plans to the Commissioners.*) *Supplement Plates* 1-13.

8797. (*Sir George Armytage.*) I understand you to say that a great deal of that coke made in those coke ovens comes from other collieries?—Yes.

8798. You could not keep a plant going like that with your own colliery?—Not at one colliery.

8799. Therefore, it is more economical to draw it altogether to one big plant than for each colliery to have a separate plant?—That is so. That is all done on our own private railways. We have a series of private railways.

8800. Do all the collieries belong to the same firm?—Yes.

8801. Would it be more economical if one large firm had a large plant like this, and bought their coal from other collieries, and made it into coke, than it would be for each colliery to put up its own separate plant?—Yes, it would be; but the difficulty would be to arrange for getting it.

8802. The larger the scheme it is worked on, the better it is?—Yes; you can see it from the capital expenditure, if necessary.

8803. (*Chairman.*) Is that subject to this qualification, that to work economically there is a minimum, and you put the minimum at four of those sets of ovens?—Oh, no, you can put up one bench of ovens—25.

8804. And work practically as cheaply as with the 4?—Probably not quite so cheaply, but it is being done in several places in England—25 to 30 at one colliery.

8805. (*Mr. Bell.*) Do you know if the proprietors of this kind of coke-making plant in Germany are importing English coal for the purpose of making coke there?—I cannot say.

8806. They are as a matter of fact, I believe?—I have never heard it mentioned.

8807. I am supplying one of them with coal for the purpose?—I did not know.

8808. (*Mr. J. S. Dixon.*) The Beehive oven coke is preferred from its appearance to a great extent?—Yes.

8809. Are the constituents of the two kinds of coke much the same?—They are made from the same coal. The analyses of the two cokes would be exactly the same.

8810. The prejudice against the one is principally the appearance and the size?—That is so, in my opinion.

8811. In regard to briquettes, they are principally made in remote districts where there is not a market for the small coal?—That is so.

8812. In a great majority of the colliery districts there is sufficient market for the small coal by itself, or in the shape of nuts?—Yes.

8813. That is the reason briquettes are not more universally made?—That is so.

8814. (*Mr. Young.*) Do the prices given in your statement represent the present prices?—They were the prices a month or six weeks ago.

8815. The amount of dirt that you gave, amounting to 6·1, seems to be excessive. Have you any fines put upon the men in respect of that?—We used to have direct fines. We have not got that system now. The system four or five years ago was for us to select hutches from the colliers at random and put men on specially to test them for rubbish, and according to the quantity of rubbish found they were penalised, and a certain deduction made from the weight at the end of the day. That was declared by two English decisions, I think, to be illegal. The Miners' Unions called upon us to depart from that means of keeping the coal clean.

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8816. What means do you adopt now?—We have latterly agreed to settle by arbitration the method of deduction. What we wanted was to be relieved from any loss due to the dirt sent up in the coal. We held that our bargain with the collier was to pay for the clean coal only. The difficulty was to allocate the deduction in respect of any special collier, because some men filled more cleanly than others. Our own penal system fined the men justly. The system that was fixed by arbitration was that we should take the total amount of dirt washed and picked on the picking table from the coal during a month, and divide that by the total number of tubs of coal put out during that same month. That brings out, as you see, from 50lbs. to 80lbs. of dirt per hutch. That is added on to the tare of the hutch for the next month. Therefore every collier in the pit gets paid 80lbs. less for his hutch than its total weight. So that whether the man fills clean or dirty coal, he has to suffer the deduction of 80lbs. The man who fills the dirty coal really gets the advantage.

8817. The man who fills the clean coal gets penalised the same as the other?—Yes.

8818. (*Chairman.*) Is that a monthly operation?—Yes.

8819. Therefore what I will call the percentage of dirt found in the month of October operates as against the month of November as regards the deductions?—That is so.

8820. (*Mr. Young.*) Is that the only check you have?—Well, we have test hutches still, and if a man puts out an excessive quantity of dirt we warn him first and dismiss him afterwards.

8821. Have you any fixed quantity at your collieries as to what is an excessive amount?—Yes; we consider that 50lbs. to 60lbs. is an excessive quantity.

8822. If the hutch contains that quantity?—Yes, and that is only over a five-eighths mesh. It does not include the very fine dirt that comes out in the smallest sizes of washers.

8823. Is there any check put by the men upon any of their fellows in respect of sending out an excessive quantity?—Very, very little, if any at all. We get almost no assistance from the men.

8824. (*Chairman.*) Notwithstanding that the careful man is really punished for the careless man?—That is so.

8825. (*Mr. Briggs.*) You speak of the repairs of the ovens being excessive owing to the moisture in the coal. Are you able to repair them with local fire bricks?—Well, the original blocks were made with local fireclay, but they were not a success, and I do not think there is any fireclay produced locally that would do, but we have been making flues with small bricks, and we find from our short experience they are likely to be fairly successful—more successful than probably the others were.

8826. From local bricks?—Yes. We have some made by hand in Belgium which were guaranteed to contain not less than 82 per cent. of silica, and these blocks have stood exceedingly well, so far as they have gone, much better than the local fireclay.

8827. Of course, the repairs of these ovens are a heavy drawback as compared with Beehive ovens?—Yes, the repairs are very heavy.

8828. Have you any experience of the average life of an oven?—Yes; we have had to re-line very often inside of two years from the building of it.

8829. That means almost a re-building?—Oh, no, it is just the lining inside. It is easily repaired; the top arch protects the main building. There are two main side walls, and you take out the inside lining and the inside arch, and it leaves the superstructure quite whole.

8830. Are you able to repair one oven without putting off the oven on each side of it?—No, we cannot do that, because of the heat; we put off three ovens to repair one.

8831. Is there any iron or steel in it, or is it all brickwork?—All brickwork inside. Of course, it is bound with iron outside.

8832. And the doors are iron-framed?—Iron-framed, lined with brick.

8833. You said that a short time ago your colliers reduced their hours from 10 to 8?—That is so. *Mr. J. T. Forgie.*

8834. Did that mean actual working hours at the face?—Yes. 27 Jan. 1903.

8835. They work 8 hours at the face now?—No, they only work about 6½ to 7 hours at the face now.

8836. Are these 8 hours regulated arbitrarily from bank to bank?—No, it is about 8½ hours. It was meant to be 8 hours from bank to bank; but, as a matter of fact, it means from 8½ to 8¾ hours from bank to bank.

8837. That is not dissimilar from the practice in the Midlands?—No. Of course it was a reduction of two hours from our previous practice.

8838. You say that that has led to greater hurry and therefore to greater dirt. You find that dirt has increased since that?—Yes; that has been our actual experience.

8839. Has the collier managed to get as much coal in his shift now as he used to do?—There has not been very much reduction, but there is a little reduction—a noticeable reduction.

8840. He has sent a great deal more dirt out?—Yes.

8841. Which, of course, is a great disadvantage to everyone?—Yes, to everyone. It is only in Lanarkshire, I should mention, that this took place. In Fifeshire they have had the 8 hours for a long time.

8842. (*Professor Hull.*) I want to put one question of a general kind, bearing on the resources of the Clyde basin, the Lanarkshire coalfield. It was stated by a former witness from that district that the lower carboniferous limestone coals are supposed to thin and deteriorate towards the centre of the basin, the Bothwell and Hamilton districts. Do you concur in that view—I do.

8843. Compared with Stirling, which lies to the north-west of that district, you also think that the coals thin out and deteriorate in quality towards the centre?—Yes, from my knowledge and experience.

8844. Do you attach importance, looking at it from the question of resources of the Scotch coalfields, to these deep-seated bottom coals of the central part of Scotland?—No, I do not; especially, I might say, in that district. Take Stirlingshire, where these coke ovens I have mentioned are situate; the seams there are probably in their best condition. We have taken large areas away to the south, and coming exactly in the direction of the Hamilton and Bothwell coalfields, the centre of the basin. Our experience where we are working and where we have bored is that the seams are gradually getting thinner and of poorer quality.

8845. You have actually worked them?—Yes; and further south a deep bore was put down by another firm, and they got the seams practically unworkably thin, 6in. instead of 3ft.

8846. On the other hand, the limestone itself increases in thickness towards the centre of the basin coming south?—Yes.

8847. (*Mr. Sopwith.*) You have mentioned some seams in which the large coal would be useful, but the coal was not worked on account of the large amount of dross which would be made which was not suitable for coking. Of course, presumably that is not lost to the resources of the country, but does the working of those seams, say at the present time, depend entirely upon the conversion of that dross into briquettes?—Yes.

8848. You do not think it would coke?—It will not.

8849. Has there been any coal, or is there any coal now being converted into coke that was considered not sufficiently suitable before?—Oh, yes.

8850. In Scotland now?—Yes, in our district, and one or two other districts, too.

8851. I do not know whether you have gone into the question as to whether the quantity of water, that is to say, natural water in coal, interferes with the coking qualities?—Oh, yes, I think there is no doubt about it.

8852. You think a lot of bituminous coal which contains a large amount of hygroscopic water, if free from water, might be converted?—Yes; we have the Ell coal and the Main coal seams, which would coke to some extent—I mean if they contained less moisture. They

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Mr. J. T. Forgie.

27 Jan. 1903.

contain at the present time anything between 7 to 10 per cent. of natural water; and if they contained as low as 3 or 4 per cent., the same as the true coking coals do, in my opinion they could be used for coking.

8853. You think 7 to 10 per cent. is prejudicial?—Yes.

8854. Of course, there is a good deal of coal in the kingdom containing 12 to 14 per cent. of water, which presents the appearance of making coking coal. If they could be dried in any economical way it is possible that these coals could be coked?—Yes, if you could dry them without affecting the coal in any way.

8855. The mechanical structure of the coal?—Yes. That, of course, would be the difficulty.

8856. (*Mr. Brace.*) For cleaning the dross from the coal is there any effective system you know of other than by washing?—Not for cleaning the rubbish from the small coal.

8857. Washing is the only system?—Yes.

8858. It is rather a wasteful system?—Not nowadays.

8859. Is there not a good deal of the coal lost by washing?—No, not by the modern washers.

8860. It is all recovered?—Nearly all. I think you will find I have said that in the felpsar I think there is only 2 to 3 per cent. of the rubbish which is free coal—that would be only one-seventh or one-eighth per cent. of the total output lost; at any rate, much less than 1 per cent. of the total output lost.

8861. The machinery devised is so delicate that it can work it to that nearness?—Yes, with a little attention, of course.

8862. You make your coal into different sizes through screens?—Yes.

8863. Do you bring all the coal in the mine out?—Yes.

8864. How are the workmen paid?—By the price per ton.

8865. Are they paid by the whole coal in the tram?—Yes.

8866. Has that been the system so long as you can remember?—It has been the system in Scotland since I have been connected with it. There have been districts where the men have been paid larger prices for the large coal and smaller prices for the small coal.

8867. Not within your experience?—Yes; but it has never been the system, as I understand, to pay nothing for the small coal—they have always got something for it.

8868. Even when the payment was upon the large coal there was a payment for the small?—I think so; in every case I know of there was.

8869. You could not tell me the amounts of the payments upon the large and the small?—It is a very long time ago since that system has been abolished in Scotland, and I really could not say; but probably it would be twice as much for the large coal as for the small, if not a little more.

8870. You say in your evidence (Par. 30), "The produce of this colliery." What colliery is that?—It is the Bothwell Castle, Nos. 1 and 2

8871. "Is sold as under: (1) Screened coal shipped to France, Egypt, Germany, Italy, and Denmark." What is the relative quantity of the output of this colliery that you send abroad?—I think you will see I have mentioned the figures, that out of 13,419 tons about 3,500 go abroad as shipment coal—that is in large coal only. Of course, a large proportion of the small coal goes abroad, and until recently that house coal all went abroad.

8872. What countries' coal would you meet in competition in those Continental markets?—That is not my line of business. I am hardly capable of saying with any authority.

8873. (*Chairman.*) I have no objection to your saying, but if it is not reliable we had better get it from someone else?—It is not reliable.

8874. (*Mr. Brace.*) I should be glad to have it from anyone; it is a very important point to have upon this question, because we want to find out the relative position for competitive purposes between our own coal and other countries' coal—I should not like to give it with any authority.

8875. I was going to follow that up by asking with what result, favourable or not. You will remember you said that briquettes could be used in locomotives and on the Continent, in France and Spain especially, large quantities of briquettes are made, and Welsh briquettes for locomotive use. Do Welsh briquettes—I am speaking now of Welsh briquettes as used upon the Continental railways and for steamship purposes abroad—made from Welsh small coal enter into serious competition with this country's large coal or other countries' large coal? Could you tell me that?—I am afraid I could not answer that.

8876. If you say that you have not any information, of course, I will accept your statement immediately. You have given evidence and Mr. Young has been asking you about the collier filling his coal carelessly. You have a right of deduction under the Mines Act, have you not?—We have a right of arrangement for a reduction.

8877. Yes, "arrangement." That means a right of deduction if you can arrange?—Yes; that is just the difficulty—we cannot.

8878. You say you have an arrangement?—Yes.

8879. By which every month you strike an average of the total quantity of rubbish and divide it between all the men, whether they send out rubbish or not?—Yes.

8880. Is that not a breach of the Mines Act?—No.

8881. I am simply asking for my own information, and the information of the Commission?—No, in my opinion it is not. I am prepared, if you care to listen, to give you instances to show it is not.

8882. If you say it is not I accept it at once, but it does seem to me not to be a fair arrangement, and not to be the best arrangement either, that those who do not fill rubbish out should have to bear a burthen for those who do fill rubbish out?—I quite agree with you.

8883. I think that if it could be brought down individually you would be able to have cleaner coal sent out, and therefore your resources would be that much more valuable?—We had it individually at one time, and the miners' leaders stopped it. It was declared illegal by two decisions—one was at Netherseal, and one in England.

8884. That was small coal?—Yes, but it affected this question.

8885. You say, "As time goes on much more of the inherent value of coal will be taken from it, and the methods of preparation of the coal may have to be changed and improved to suit the different conditions under which coal may be used in the future." What had you in your mind when you stated that?—I will tell you what I mean by it. The consumer and the user of the coal must adopt some other methods to take the whole value out of the coal than those adopted at present. It may entail upon us different arrangements for preparing the coal if the consumer uses it in a different method from what it is used at present. Our present method is due to the present use of the coal, but I think the great economy in the future is to be found in the proper using of the coal.

8886. Improved appliances for using, say, small coal?—Yes. At the present time we are taking a very small proportion of the real value of the coal out of it.

8887. (*Chairman.*) Have you given any attention to that particular question, and have you got figures in your mind as to the percentage which is got, for example, with an ordinary stationary boiler?—I have no definite figures, but from general knowledge and what I have understood, we are taking only about one-fourth to one-fifth at the very most, and probably much less than that, of the real value of the coal out of it, especially in colliery boilers. I think it is even worse than that.

8888. (*Sir Lindsay Wood.*) I think you said that there used to be a good deal of coal wasted in the mines in Scotland?—Yes.

8889. Is that being done now?—To a very, very small extent—I think almost to no extent now.

8890. It is abandoned?—The washing and the improvement of the small coal has encouraged the raising of it.

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8891. You said that by using plates with round holes instead of bars you got less of the dross taken out. Is that due to the particular condition of the coal?—I think the coal is better screened over round holes than over bars. With the bars there used to be a good many pieces of long coal of a thickness to go through the bar, and those would now go in with the round coal. With the round holes they slip over and do not go through. The coal at the same time is better screened.

8892. You get less dross taken out over the holes than with the bars?—Yes.

8893. You are using the Robinson washer?—We are using one or two.

8894. Do you consider them economical?—No, they are not. The coal that you do get is washed fairly clean, but there is still a large quantity of coal lost in the rubbish.

8895. You have substituted the German plant?—Yes.

8896. You say in your evidence that the coke is sold for foundries at 21s. a ton at the ovens, and you also give the price of coke that is sold to the furnaces at 12s. 9d.?—Of course, that is for a very different quality of coke; it is not made from the same coal. The inferior coal is made into coke in the patent ovens. We have two qualities only: the finest coal is made by the Beehive ovens into foundry coke, and the other is made from an inferior coking coal—considerably inferior.

8897. And does not command so high a price?—It does not.

8898. The difference is very large?—Yes. We get a very high price for foundry coke in Scotland at the present time.

8899. I suppose there is a special demand?—Yes.

8900. Is the building of patent ovens increasing in Scotland?—There are scarcely any built there except our own. As I have mentioned before, there are two other small plants, but with those exceptions there are none. *Mr. J. T. Forgie.* 27 Jan. 1903.

8901. They are all using the Beehives?—Yes; the coke made in Scotland is a very small quantity altogether.

8902. Do you think that this large plant you have described to us is enabling you to use inferior coals economically?—It is.

8903. And also to avoid waste in the best coal?—Yes; that is to say, we can make the coke with 5 to 6 cwt. less than the Beehive ovens.

8904. That justifies the large capital expenditure?—Yes; that, of course, and the bye-products, especially in a large plant like this, where you can command plenty of coal always to keep the ovens going. It would be ruination, of course, if we had to throw off any of that plant to stand for some time through the want of coal.

8905. Do you think there is any likelihood of saving in the produce of the coal—I do not mean in the consumption, but the production of coal from the colliery—is there likely to be much increase in utilising a larger proportion of coal in the seams by any improved method of working?—Oh, no. The Scotch collieries at the present moment are losing almost no coal. In the Bothwell and Hamilton districts the figures recently show that the coal there is being worked very economically with almost no loss.

8906. Then there is not much room for improvement there?—I do not think so, in Scotland.

8907. It is more likely to be obtained in the consumption?—That is my opinion; it lies more with the consumer in future to bring out economies than with the producer.

Mr. JOHN H. DARBY, M.Inst.C.E., called; and Examined.

8908. SUMMARY OF EVIDENCE.

Mr. J. H. Darby. 27 Jan. 1903.

(1.) Coal Washing.—I have found, dating from about the period 1895-1900, a great falling off in the quality of small fuel, usually reserved for washing and coking purposes, so that washing apparatus which was adequate to deal with the former qualities is no longer suitable. In cases under my notice at present, small fuel for washing contains over 50 per cent. so small as to pass a ⅛in. mesh.

(2.) The falling off in quality is probably due (1) to the more efficient means of cleaning coal by picking-belts, etc., now largely adopted, which enable colliery owners to send away more small fuel in the round coal; (2) to the use of high explosives, which shatter the coal and cause a larger percentage of dust; (3) to the increased working of thin, inferior, and dirty seams.

(3.) In my experience the smallest fuel carries the largest proportion of refuse, and is by far the hardest to wash clean without an undue loss of small coal, while at the same time the resulting washed fuel may retain a large percentage of the detrimental wash water, more than 10 to 12 per cent. of which in the washed slack should be avoided for subsequent coking operations.

(4.) The points to be considered in washing are (1) to obtain from the fuel the largest possible quantity of clean and fairly dry coal without an undue loss of fuel in the refuse; (2) cheap and efficient handling of fuel and refuse; (3) simple and reliable apparatus in the washer that will not easily get out of order under the dirty and trying work it has to perform; (4) low first cost, which is almost impossible unless a large washery of 75-100 tons per hour capacity is erected; (5) the return of all wash water, which, if allowed to escape, is often a great nuisance.

(5.) There are many modern washeries which answer the conditions imposed in a greater or lesser degree. In my experience, however, for very fine fuel they must be of the feldspar type, and even then, where it is possible, as much of the finest portion of the fuel as is admissible from an ash point of view should be separated from the dry fuel and regularly added to the washed portion.

(6.) Drainage of the fuel after washing is best accomplished in large water-tight tanks capable of holding the products of a whole day's washing—the wash water always returning to the washer after the fine coal has deposited. Drainage pipes are opened at the end of the day, and in 48 hours the washed fuel, containing the very small portion, does not hold more than 10 to 12 per cent. water.

(7.) With properly selected washing plant even the small coal of to-day, containing 50 per cent. of small under ⅛in. mesh and 25 per cent. of stony refuse, can be washed and dried so well that after grinding and compressing, it can be made into marketable coke with 88 per cent. of fixed carbon.

(8.) My own experience does not extend to washing fuel larger than that passing 1½in. mesh. In cleaning the run of coal from a colliery, I maintain that all coal under 3½in. to 4in. mesh should be graded and washed, as a much cheaper and more efficient means of cleaning the coal from refuse than picking by hand. At collieries where I have seen this method in operation the warmest opinions were expressed as to its merits both from a producer's and consumer's point of view.

(9.) I would go as far as to say it is very seldom indeed that it pays anyone to burn fuel containing more than 10 to 12 per cent. of ash, and the saving in carriage by paying railway rates on useful fuel only, and not on rubbish, must be considerable.

(10.) Large modern washing plants can wash fuel, including all charges, at 1½d. per ton.

(11.) Coke Ovens.—These may be divided into three types: (a) The Beehive; (b) the retort oven without recovery of bye-products; and (c) the retort oven with recovery of bye-products.

(a) In the Beehive and similar ovens air is admitted into an arched chamber above the fuel to be coked, for the purposes of burning the volatile products of the coal as they are distilled by the existing heat of the oven and for affording additional heat to complete the operation. The air so admitted burns a considerable quantity of solid carbon in addition, and thus reduces the yield of coke.

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Mr. J. H. Darby.

27 Jan. 1903.

Generally speaking, no bye-products are collected from this type of oven, and there is a wastage of 10 to 15 per cent. of the fixed carbon in the coal.

Boilers are often interposed in the flues between the ovens and the chimney, and a considerable amount of steam is thus generated. The quantity of water evaporated varies with the amount of fixed carbon wasted in the oven, and with the amount of volatile matter in the coal. I have observed over 2lbs. of water evaporated to steam per 1lb. of coke made. Burning fixed carbon or coke for the sake of generating a little extra steam is very doubtful economy. Using fuel containing 30 per cent. of volatile matter, 52 to 54 per cent. of dry coke is a usual yield.

These ovens often produce 7 to 8 tons of coke per week; they demand little attention in burning, produce first-rate, bright, and dry coke from good coking coals, but are extremely wasteful. To produce 1,000 tons of coke per week the outlay, without boilers, would be about £5,760, and with boilers, hearth, flues, sidings, etc., an average cost would be £5,760 plus £3,000 for boilers, plus £4,720 for hearths, sidings, etc., equals £13,480.

In Beehive ovens 1,000 tons coke = at 54 per cent. yield from 30 per cent. volatile coal, 1,850 tons fuel.

In non-recovery ovens 1,000 tons coke = at 64 per cent. yield from 30 per cent. volatile coal, 1,560 tons fuel.

In recovery ovens 1,000 tons coke = at 68 per cent. yield from 30 per cent. volatile coal, 1,470 tons fuel.

Therefore in producing 1,000 tons of coke per week the Beehive ovens burn or waste 1,850 — 1,470 = 380 × 68 per cent. = 258 tons of coke = at 14s. 6d. per ton, present price, a loss of £187 per week = at 50 weeks £9,350 per year.

(b) The non-recovery retort oven, in which the fuel chamber is often long and narrow, The products of distillation are ignited over the upper surface of the coke, which is small in proportion to the whole, and pass down flues arranged in the brickwork forming the dividing walls between two ovens. These ovens often work in pairs, the waste heat from one heating the flues and in turn carbonising the fuel in the next oven.

This type of oven is charged from the top, or compressed coal is forced into the oven through the rear door, and the coke is discharged on to a hearth by means of a ram. For fuels so low in volatile constituents that it does not pay to collect the bye-products, these ovens are best suited. The yield of coke is good, the ovens are simple in construction, and for a production of 1,000 tons of coke per week, including, in addition to the ovens, rams, sidings, hearths, boilers, chimney, etc., complete, the average outlay will be about £15,200. The coke burnt or wasted in these ovens in producing 1,000 tons of coke per week would equal 63 tons per week, worth, at 14s. 6d. per ton, £2,250 per year of 50 weeks.

(c) The bye-product or recovery oven.—This, in 1902, produced about 1,045,000 tons of coke, or about 10 per cent. of the total production of coke in the United Kingdom.

The object of this class of oven is to coke fuel in a closed retort heated from the outside by means of flues. The products of distillation are conducted away as produced, cooled, and the tar, ammonia, and benzole collected by suitable means. Part of the resulting scrubbed gas is then passed forward to the ovens, and, after regulation, burnt in the flues mentioned. A uniform heating of the oven walls should be secured, and the waste heat or spent gas from these flues is collected in a flue and passed under boilers, where about 1½lbs. of water are evaporated to steam per pound of coke made, and afterwards, the spent gases, so cooled, are allowed to escape into a chimney. The remainder of the scrubbed gas is available for lighting, heating, or power purposes. From coal yielding 10,000 cubic feet of gas per ton, and having a calorific value of 480 to 500 B.T.U. per cubic foot, there is 3/4000 cubic feet of spare gas per ton of fuel coked. This amount, given off over 24 hours, multiplied by 7 tons the quantity of fuel per charge, equals, if burnt in a gas engine, about 40 brake horse power per oven.

(12.) Recovery ovens are usually charged through holes in the top of the oven, which are afterwards closed with lids. During the last two years the washed and ground fuel to be coked has been first stamped into a box, and a cake so formed rather less than the oven; the bottom of the box which is movable is then driven forward, after the sides of the box are released, carrying with it the cake of fuel; the oven doors are shut, and the movable bottom afterwards withdrawn. Compression of fuel in this way improves the quality of most cokes, making them denser; 25 to 30 per cent. more fuel can be introduced into an oven, but owing to slower coking the net gain is about 10 per cent. in production compared with similar ovens working with uncompressed charges.

(13.) In one case in Lancashire, in my own knowledge, large areas of coal that had previously been condemned for coking purposes have now been made available through compression of the fuel before coking.

(14.) The improvement in quality by compression does not always follow, however. The South Lanarkshire district in Scotland produces a coal which cokes fairly well in a Beehive oven, but the coke made in a retort oven with side heat is generally worthless. I found that in order to obtain useful coke the shape of the oven had to be altered, and a low crowned rectangular oven about 30ft. long was arrived at. The heating flues in this oven were so arranged that coking proceeded from the bottom upwards—the fuel was heated from the bottom and not from the sides. A satisfactory coke was thus produced, while the bye-products were collected, and mechanical arrangements for charging and discharging with fuel compressing machines and rams retained.

(15.) My experience goes to show that each description of coal must be examined by itself, and treated as occasion demands. No hard and fast line can be laid down as to which is the best method of coking. It is a fact, however, that many fuels not previously considered as coking coals may be made into useful coke under conditions suiting their composition.

(16.) With regard to bye-products, rich bituminous gas coals usually give the highest yield of bye-products, *i.e.*, tar, ammonia, light oil, and surplus gas. In my experience there is no laboratory method that will give more than an indication of the quality of coke to be expected, or the yield of bye-products to be obtained; conditions vary so much between the laboratory and actual practice.

(17.) I have had satisfactory experience of ovens working with coal containing 16 per cent. volatile matter erected by the patentees at their own cost, where payment for the outlay was made by the bye-products produced being handed over to the builders for a term of years. Probably lean coal of this description is about the limit where bye-product ovens can be profitably employed.

(18.) From 16 per cent. volatile matter upwards the yield of bye-products increases, and at 30 to 32 per cent. the limit is reached. With a rich coking coal of this description the present net value of the bye-products, tar, ammonia, and light oil, after deducting cost of collection, amounts to over 5s. per ton of coke.

(19.) I have had experience of rich coals yielding 5 to 6 per cent. of their weight of tar, 37lbs. of sulphate of ammonia, and 31/3 gallons of 65 per cent. naphtha per ton.

(20.) As in the case of non-recovery ovens, the coke is discharged on to, preferably, a sloping hearth by means of a ram, and automatically quenched as it leaves the oven door. The resulting coke is silvery, bright, and dry, and may be readily loaded into wagons, etc., for delivery.

(21.) Patent compressed coke (as it is called) so treated fetches, in my experience, at least 1s. per ton more money than Beehive coke made from similar fuel.

(22.) For a production of 1,000 tons of coke per week, including, in addition to the ovens, compressing and charging plant, rams, sidings, coke hearth, boilers, chimneys, bye-product plant complete, the average outlay would not be less than £40,000.

(23.) The coke burnt or wasted in the ovens is nil, and in a case under my notice the average net value of the bye-products from 1,000 tons of coke amounts to £250 per week, or × 50 = £12,500 per annum. Compared with

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the Beehive oven, therefore, for the same production of coke, viz., 1,000 tons per week, there is a saving of £9,350 (value of coke wasted)+£12,500=£21,850 per annum—the costs of erection being £13,480 in case of the Beehive, and £40,000 in case of the recovery oven. The above values are for a rich 30 to 32 per cent. volatile coal. The returns in bye-products from a 16 per cent. volatile coal would not probably be half those stated.

(24.) With well designed and constructed recovery ovens repairs are not excessive. I have known ovens at work without repairs for nine years. On the other hand, with faulty material, repairs have been heavy.

(25.) I know of no refractory clay in the United Kingdom suitable for the linings of retort ovens. I have examined nearly 100 different varieties of the well known British clays without success. Linings for retort ovens are usually bought from Belgium and Germany.

8908.* (*Chairman.*) I understand that you have given great attention to the question of the preparation of fuel for metallurgical purposes. Does that mean for the smelting of iron and other such purposes?—I mean the preparation of fuel first by cleaning and subsequent preparations for coking.

8909. Now you say that there has been a great falling off in the quality of small coal since about 1895?—Yes.

8910. Is that due to the fact that in what you call the small coal there is a greater proportion of rubbish now?—Not only rubbish, but there is a greater proportion of almost dust coal.

8911. You attribute that partly to the fact that the more careful preparation of the coal for the market takes out of what you call the small coal a larger proportion of the rather larger coal; is that it?—Yes; the better methods of cleaning the larger coal enable the colliery proprietors to sell more of the small coal as large coal; and the portion which goes forward for washing and coking is very much more difficult to treat.

8912. In speaking of the modern washeries you refer to the fact that in your own view for very fine fuel they must have one of the feldspar type?—Yes.

8913. That is a layer of feldspar at the bottom?—Yes, which separates the coal from the dirt which is rejected.

8914. You say, "With properly selected washing plant even the small coal of to-day, containing 50 per cent. of small under one-eighth inch mesh and 25 per cent. of stony refuse, can be washed and dried so well that after grinding and compressing it can be made into marketable coke with 88 per cent. of fixed carbon." Is 88 per cent. of fixed carbon a good average?—I think it is for the coke of to-day. I think anything about 10 per cent. of ash and the balance for water is about the average coke of to-day.

8915. What would you consider to be properly selected washing plant?—I have in mind many. They are almost all German plants. There is a washer made by the Humboldt Company, another is the Luhrig washer, and there is the Baum washer—all washers belonging to that class.

8916. About what would be the cost of washing with a modern plant on a large scale?—Say a plant that would wash 100 tons an hour; I know from my own knowledge that that is being done at about 1½d. per ton.

8917. That is what you would call the labour and the cost of the plant?—The labour, the stores, and the power.

8918. (*Sir George Armytage.*) The interest on the outlay?—No.

8919. (*Chairman.*) That is really the process of operating?—That is so.

8920. That is 1½d. per ton upon the fuel operated upon?—Yes.

8921. Of course there would be a loss?—Yes, which will represent the dirt removed from the fuel.

8922. Does that sum cover anything more than the mere washing? Does it cover what we have heard about the allocation of it into different sizes and so on?—That covers the dumping of the fuel into the bunkers, to start with, and the delivery of the fuel into the final wagon or the receptacle provided for it, and the disposal of the refuse—the tipping of it.

8923. This is done from the screen, I suppose. Would the small coal at the point where it is screened find its way into these trucks, and so on?—In washers of the size I name it is generally necessary to assemble the fuel from several collieries.

8924. You contemplate a washer that would do, as you say, 100 tons an hour?—Yes.

8925. Therefore that really means bringing and putting it into bulk?—It means bringing the fuel from the sources of supply.

8926. Can you rely upon the continuous supply if you have to bring it from a distance without a second handling?—In plant I am acquainted with the usual way is to bring the fuel in railway wagons and assemble it from the various collieries. One colliery in itself is hardly sufficient for that.

8927. And there is the stock in the railway wagons?—That is the elastic portion.

8928. That would be sufficient to keep the continuous operation going without unloading it?—That is so.

8929. Is that in England or in Scotland?—The plants that I am thinking of are in Westphalia.

8930. Are any plants in operation in this country of this type?—Oh, yes, a number of them. The previous witness (Mr. Forgie) has a fine washery of that type at Messrs. William Baird and Co.'s collieries.

8931. Then you speak of boilers being interposed in the flues between the ovens and the chimney. That is another way of stating that what are called the waste gases are used for the purpose of raising steam?—That is so.

8932. Does your 2lbs. of water evaporated to steam per 1lb. of coke made mean that the waste gases are fully utilised?—I do not say that more might not be got out of them.

8933. Then you say, speaking of certain ovens, "To produce 1,000 tons of coke per week the outlay, without boilers, would be about £5,760, and with boilers, hearth, flues, sidings, etc., an average cost would be £5,760 plus £4,720 for hearths, sidings, etc., plus £3,000 for boilers, equals £13,480." I do not quite follow those figures. Is it £13,480 to produce 1,000 tons of coke per week?—That is so.

8934. What is the average cost? Does it mean the weekly cost?—The capital outlay.

8935. You look upon the Beehive oven as being more wasteful than the modern patent retorts, as they are called?—I think very much more wasteful.

8936. That is due mainly to two causes, a larger amount of coal is used per ton of coke, and there is not the recovery of the bye-products?—Yes, those are the two causes. The fuel is burnt in the oven itself.

8937. I understand you to say that 90 per cent. of the coke produced in the United Kingdom is made in ovens other than the bye-product or recovery ovens?—That is so, I believe.

8938. That you look upon as being very wasteful?—Yes, I do, but there are coals that it is not economical to treat in a bye-product oven.

8939. (*Professor Hull.*) Only the coals that are rich in tar would be useful for producing bye-products, highly bituminous coal?—Yes. There is a great range of coal from the lean coal to the very rich ones, and when you get coals containing 16 to 17 per cent. of volatile matter I think it no longer pays to collect the bye-products.

8940. It passes into the steam coal character?—Yes.

8941. (*Mr. Young.*) Would there be a much larger demand for bye-products if they could be sold 20 per cent. cheaper?—The sulphate of ammonia, which is the chief bye-product, retains its value with the increased production that is going on. I am afraid I could not answer that question. There seems to be plenty of demand for it.

8942. (*Professor Hull.*) That is for manure purposes principally?—Yes.

8943. (*Mr. Young.*) Do you think the use of that

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Mr. J. H. Darby.

27 Jan. 1903.

would be increased very largely if the price were reduced, say 20 per cent.?—Yes, in my opinion the consumption would increase.

8944. And if the price was lessened by 20 per cent., would it be profitable to make?—The price of sulphate of ammonia to-day is about £11 10s. a ton, and it can be made for very much less than that.

8945. (*Chairman.*) It is a little difficult to know what increased uses may be found for the bye-products?—Yes; I believe that sulphate of ammonia is almost entirely exported.

8946. May I take it that your figures of the total production of coke in the United Kingdom is about 10,000,000 tons a year?—Yes, or rather more. It is difficult to get at. I do not know of any returns to show it, but it is taken from the production of pig-iron.

8947. Coke is used for other purposes besides the production of pig-iron?—The figures spoken of are taken from the production of the amount of sulphate of ammonia, of which returns are obtainable.

8948. (*Mr. Briggs.*) That is 1,000,000 tons?—A little over 1,000,000 tons.

8949. (*Chairman.*) I was trying to find out whether that 1,000,000 tons was 10 per cent. of the total?—I carefully say "about." It is calculated from the pig iron production.

8950. That is the best estimate you can make?—Yes.

8951. Have you any experience of the use of compression?—Yes.

8952. Is it an improvement?—In the majority of cases.

8953. What form does the improvement take?—The coke is a denser coke. There are coals that I have had experience with that would not make a marketable coke when treated in the old way, but after compression they have formed a marketable product.

8954. Therefore we may take it that in two forms it may be an improvement, in the one case enabling coal which otherwise would be inferior for the purpose of coking to be used, and in the other case improving the quality of the product?—That is so.

8955. You say that whilst no hard and fast line can be laid down as to which is the best method of coking, it is a fact, however, that many fuels not previously considered as coking coals may be made into useful coke under conditions suiting their composition?—That is so.

8956. Does that mean the methods of operation, or including compression?—I intend that to refer to the methods of cleaning the coal, washing it, and grinding it—compressing and coking in ovens that seem to suit the character of the coal that you are treating.

8957. I take it as a general proposition that coal which can be used for coking purposes has a greater value than coal which cannot?—Certainly.

8958. And, therefore, any process by which coal can be made available for that purpose has the effect of raising the value of the coal?—That is so.

8959. Then you say in your statement: With a rich coking coal of this description the present net value of the bye-products, tar, ammonia, and light oil, after deducting cost of collection, amounts to over 5s. per ton of coke. How many tons of coal do you reckon to a ton of coke?—With coal of that character about 100 tons of coal would make about 70 tons of coke.

8960. Then it is 10 to 7?—10 to 7.

8961. Therefore that is 35s. divided by 10s.—that is, 3s. 6d. per ton upon the coal?—Yes, but many coals give very much less than that.

8962. Is "patent compressed coke" another way of describing coke which is made from compressed coal?—Yes; "patent coke" as I know it, is a term which is applied to all coke made in recovery ovens.

8963. Where does the compression come in then?—When I say "patent coke" that is coke made in the recovery oven in which the fuel has been compressed prior to cooking.

8964. I quite understand now. You put at least 1s. per ton on to the value?—In speaking of two instances that are under my notice daily, of two plants coking similar fuel from the same district, in one plant the fuel is compressed, and in the other plant it is not compressed; the difference in price realised for those two cokes is 9d. to 1s. per ton in favour of the compressed coke.

8965. Then in your statement you give us some interesting figures with regard to the cost of plant, and you say, "For the production of 1,000 tons of coke per week, including, in addition to the ovens, compressing and charging plant, rams, sidings, coke hearth, boilers, chimneys, bye-product plant complete, the average outlay"—that is the capital outlay, I take it—"would not be less than £40,000?"—That is so.

8966. And compared with the Beehive oven, therefore, for the production of the same quantity of coke, namely, 1,000 tons per week, you estimate that there is a saving of £21,850 per annum?—That is so. That is made up of the better yield, the increase in yield, of coke from the coal and the value of the bye-products to-day. But the outlay is more than three times as much.

8967. The outlay for the Beehive would be £13,480, as against £40,000 for the other type?—That is so.

8968. (*Mr. Bell.*) You have £28,000 extra capital expenditure, and a return of £21,850 per annum; is that so?—That is so.

8969. (*Mr. J. S. Dixon.*) Does this £21,850 include the cost of the recovery of the bye-products?—That is the net.

8970. That is the net gained by the sales?—That is the net value of the sales after deducting the cost of collection.

8971. (*Chairman.*) In other words, working a concern on the one system and working a concern on the other system, the difference in saving you put as high as £21,850 per annum on an output of 1,000 tons per week?—Yes, under the conditions named.

8972. Then, as Mr. Bell puts it, you would save, in little more than a year, the extra capital outlay on plant?—Yes.

8973. (*Sir Lindsay Wood.*) Is that taking the basis of the Beehive oven producing only 54 per cent. of coke?—The Beehive oven producing 54 per cent. of yield.

8974. Is not that a very small yield for a Beehive oven?—Not in the case that I am suggesting, where the coal contains 30 per cent. of volatile matter. That is my experience.

8975. Then these figures would refer only to a particular class of coal?—That is so—a rich coking coal.

8976. There are Beehive ovens which give as much as 60 and 62 per cent. of yield?—Yes.

8977. That would make a very great deal of difference in your calculation?—In a case of that kind the contrast would not be so great.

8978. What was the percentage of coke in the bye-product oven in this case?—68 per cent., I think.

8979. 68 per cent. as against 54 per cent.?—Yes.

8980. (*Mr. J. S. Dixon.*) I suppose that coal also contained a large quantity of the bye-products—it was a rich coal in bye-products?—Yes, it was.

8981. (*Chairman.*) The inference I draw from this is that coals of a certain richness can be more economically coked in what you call the patent oven?—That is so.

8982. And there is more waste if you treat the rich coal in the Beehive oven?—Yes.

8983. Therefore, in coal not so rich, the difference as regards these figures between the two classes of oven would be less than it is in the case of rich coal?—Yes, and when you reach about 16 per cent. of volatile matter it ceases.

8984. Yes, and therefore it really comes to this, that with certain kinds of coal there would be comparatively little economy in using the patent oven as compared with the Beehive?—That is my experience.

8985. Then there is an interesting point to which you refer with regard to the design and construction of the recovery ovens and their repairs, and you say that you know of no refractory clay in the United Kingdom which is suitable for the lining of retort ovens; is that so?—That is so.

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8986. And you say that you have examined nearly 100 different varieties of the well-known British clays without success, and that linings for retort ovens are usually bought in Belgium and Germany?—That is so.

8987. In what form are they bought?—In the form of the special brick required. I think I am right in saying that.

8988. Does that apply to all parts of the United Kingdom where these ovens are used, whether in England, Scotland, or elsewhere?—To all parts of the United Kingdom where they are used. Many ovens have been erected with British-made linings; but, so far as I know, they have none of them been successes—there has been trouble with them.

8989. Do you know whether the attention of the British fire-brick manufacturer has been drawn to the matter? Does he admit that such a thing cannot be produced in this country?—They do not produce it. I should imagine that the applications which have been made to them to make a brick must have drawn their attention to the fact, and with regard to the production of a suitable lining, it has not been made.

8990. And you attribute it apparently to the absence of suitable clay, and not to the meth odof production of the brick?—I think it is both. So far as I know, there are no clays which are equivalent of the Belgian clays in that respect.

8991. There is no Belgian clay brought over to this country for the purpose of making bricks, I presume?—I never heard of any.

8992. (*Sir George Armytage.*) You told us about the large plant in Westphalia; is there any plant of that kind in this country that you are aware of?—Do you mean of the feldspar washer type?

8993. Yes?—Yes, there are a number.

8994. Are there any plants which you are aware of which are not connected with collieries, where the coal is brought from different collieries to one large centre?—Yes, I know of washeries that treat the coal from several collieries.

8995. In what part of the country are those?—I know of some in Lancashire, and I think I am right in saying that in several different districts it is the custom to assemble coal at washeries. I cannot at the moment give you the names of the places, but I am quite sure I have seen them.

8996. Is that an increasing custom?—It is an increasing custom to centralise the washeries.

8997. Those centralised washeries generally belong to the proprietors of the collieries that supply them, I take it?—Yes, so far as I am aware.

8998. So that they use one large washery in order to deal with it more economically than they would by putting up several washeries at their own collieries?—Yes.

8999. Are you aware of any cases in which there are plants of this description where the colliery proprietors have nothing to do with them—where they are separate companies, or anything of that kind?—No, I do not know of any in this country.

9000. Generally speaking, you would say that the larger the scale on which these things are done, the more economical it would be?—I certainly think that anything like 75 tons to 100 tons per hour can be treated more economically than smaller quantities. The first outlay of a washery is very great.

9001. (*Mr. Sopwith.*) But there might be no advantage in treating a larger quantity. You think that is a fair standard?—Yes, I think that is a fair amount. Everyone is fully employed in that case.

9002. (*Sir George Armytage.*) I think you put the size of the plant which you were speaking of, which was for about 1,000 tons per week, as about the minimum standard for economy?—Yes, that is a coking plant. I think that any plant for under 1,000 tons per week is not working economically.

9003. And that you put as about the minimum?—Yes, I think I should say that is about the minimum.

9004. (*Mr. Bell.*) Does your experience of Westphalia teach you that it is necessary to wash all the coal there before making it into coke?—I think the washing of coal is universal in Westphalia. I do not know of any coal that is made into coke without washing.

9005. Do you know the percentage of refuse which is taken out of coal in that operation?—It varies enormously. I have seen it as high as 25 per cent., and I have seen it down to 6 or 7 per cent. It varies with the pit; as they come from the pit, some fuels carry a great deal more stony matter than others.

9006. But it becomes an absolute necessity that if they want to make coke they must wash the coal, or the quality of the coke would be so inferior as to render it almost unprofitable?—When coke contains more than about 10 per cent. of ash it is generally refused—it is not marketable.

9007. The Westphalian coal would contain much more than that?—Yes, it would.

9008. (*Chairman.*) But I thought you told us that apart from the question of coking, the coal was washed even for preparation of the coal for the market?—Yes, I do know of cases where that is being done.

9009. (*Mr. Brace.*) That is pretty general, is it not? Has not practically every colliery in Westphalia large tanks into which to turn their coals for washing for all purposes?—My experience is that coal below 3-in. mesh is washed, and the refuse is separated by means of washing. Larger coal than that is picked That is my experience of the practice.

9010. (*Chairman.*) You are now speaking of Westphalia?—Yes.

9011. (*Mr. Brace.*) Essen is in Westphalia, is it not?—Yes.

9012. I was viewing some collieries there, it might be two years ago, and they were practically washing all their coal there, with the exception of very large lumps?—Many of those collieries produce a very small percentage of large lumps, so that a large proportion of the total comes under the size I have mentioned.

9013. (*Mr. Bell.*) I should like to ask you, in order to follow up the question which has been put, whether you consider that the people of this country have been behind the Germans in having recourse to the application of the better method of dealing with coal containing rubbish to a more or less large percentage?—I think that the question of cleaning small coal by washing received a great deal more attention in Germany than in this country.

9014. Is that because their coal contains more refuse?—There was more necessity for it.

9015. There has not been so much necessity in this country?—Not until recently; many of the coals were clean enough without washing.

9016. (*Chairman.*) Will you kindly develop that a little, because I do not quite follow it. What has been the change, as you say, recently?—In my experience, dating from 1895, there has been a great falling off in the quality of coals that have come forward for washing purposes.

9017. But I did not understand that that was anything more than, if I may so describe it, that there had been a little more of the better coal taken out of the small, leaving it relatively worse?—And I think that inferior seams are being worked.

9018. I follow you now. That was the object of my question?—I think also that the use of high explosives has had another very bad effect on the character of the small coal.

9019. It has had a bad effect on its character?—Yes.

9020. Do you mean mixing more dirt with it, or making more small?—Making it fine—making it very dusty.

9021. (*Mr. Bell.*) I think the Chairman's suggestion to you is the solution of the matter, namely, that the better the coal, the larger the proportion of pieces of clean coal picked out of the total quantity raised, and in that manner the dross or the small left must necessarily contain a larger percentage of refuse?—That is one reason, I think.

9022. That is not the main reason, I understand?—Well, that is an important reason.

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Mr. J. H. Darby.

27 Jan. 1903.

9023. Because in working the coal, whether you bring it down in a larger or smaller quantity, that operation would not destroy the quality of the coal, would it?—It makes it far more dusty; and when speaking of dust, anything that passes one-eighth of an inch mesh is dust, so far as the washer is concerned.

9024. But it does not knock the virtue out of the coal?—It does not knock the virtue out of the coal, but it alters its condition.

9025. It contains more small?—It contains more small, which is extremely difficult to treat in any of these washeries that have been arranged. That is why I think more attention is now being given to the washeries.

9026. (*Chairman.*) But as an auxiliary to the washery, there is what is described as automatic sorting into sizes, is there not?—Yes; it is generally done into perhaps two or three sizes; it depends what you begin with; if you begin with 3-in. coal, it is classified into four or five different sizes, ending with the fine, and each size is washed by itself.

9027. Therefore the washing process really increases the value of that remainder which you speak of as small coal, if it is passed through that frame?—If the stony refuse can be removed from the dusty coal, it is as good for cooking purposes as larger coal.

9028. (*Mr. Bell.*) Do you know how long sulphate of ammonia has been appreciated as a fertiliser?—A long time. The production of sulphate of ammonia amounts to, I think, over 200,000 tons per annum, and the proportion that comes from coke ovens is a very small amount of that. It is the gas works that have found a market for it.

9029. Is it true that the fear that by using these recovery ovens for obtaining bye-products, and thus bringing more sulphate of ammonia on to the market, has deterred people from embarking in this kind of industry?—I do not think that has deterred them so much as other causes. I think that the large capital outlay has deterred a great many people.

9030. But in your opinion has not the price of sulphate of ammonia been rather shaken when there has been a good deal more put in the market? It used to be as high as £11, for instance?—Yes, but it has been as low as £7.

9031. But do you know whether in putting up these plants the colliery proprietors calculated that in order that they should be remunerative the price of sulphate of ammonia must be somewhere betwen £10 and £12?—I suppose it would average about that for a good number of years past.

9032. Have you any idea whether it was the appreciation of sulphate in fertilising that led the Germans to develop these bye-products?—Partly, I think. The use of ammonia, not only as sulphate, but in other ways, was required, and I think the development of these ovens, in one case at all events, was consequent on the desire to obtain ammonia.

9033. But do you know whether a fear has arisen of there being an over-supply of sulphate of ammonia in the event of this method of utilising small coal being adopted to a large extent? Supposing 10 per cent. of this kind of coke, for instance, were converted into 25 per cent. within the next two or three years, would there be an increasing demand for bye-products?—There has been an increasing demand for sulphate of ammonia, and, of course, in many ways the demand for sulphate is affected by the agricultural question—as to whether they can buy the material. In my experience there is no trouble in selling sulphate of ammonia.

9034. (*Dr. Le Neve Foster.*) With regard to the choice of a cooking oven, I gather that it is the quality of the coal which has to decide it?—Yes, whether the coal requires coking quickly or slowly.

9035. If you have a coal with a large amount of volatile matter, you would erect a bye-product recovery plant, and if you have a coal with a small amount of volatile matter, you would erect Beehive ovens?—Yes, or the non-recovery plant—the patent oven as it is called.

9036. Then the quantity of coke produced with bye-product ovens, you say, is 1,000,000 tons, roughly speaking?—Yes.

9037. How is that quantity estimated? What statistics are there?—There are statistics which show the production of sulphate of ammonia from bye-product ovens.

9038. How are they published?—They are published in Dr. Carpenter's publication.

9039. In the reports of the Alkali Inspectors?—Yes, the Inspectors under the Alkali Act.

9040. That would give the quantity of sulphate of ammonia produced?—He gives the quantity of sulphate of ammonia produced from recovery ovens in the United Kingdom.

9041. Then you would be reckoning that a certain amount of sulphate of ammonia would correspond to a ton of coke?—The figure I took in that calculation was 20lbs. of sulphate of ammonia per ton of coal. That is the way in which I arrived at that figure.

9042. With regard to the refractory clay, is it not strange that with all the different kinds of clay and refractory materials we have in this country, we should not be able to make a brick that is suitable?—It is very strange.

9043. What are the faults of British-made bricks or British-made linings?—They crack and contract. I think perhaps from a refractory point of view there are bricks that would do, but it is the contraction and cracking of the British clays that cause a failure.

9044. (*Chairman.*) Is that because they will not stand a high temperature?—They will not stand a high temperature which varies—a varying high temperature.

9045. (*Dr. Le Neve Foster.*) Would not the temperature in a Siemens furnace be higher?—Yes, very much higher; but that is a different brick.

9046. Then, perhaps that is constant?—There is this point also; there is often a great deal of water present in the fuel. If you push a cold charge of fuel, containing 10 per cent. or 12 per cent. of water into an oven, I think the water has a great effect on the bricks.

9047. (*Chairman.*) You refer to the water in the coal?—Yes; that is given off as steam.

9048. What distinction do you draw between the lining of a blast furnace and the lining of one of these patent ovens; because the lining of a blast furnace, as I understand, is provided in this country, is it not?—Oh, yes. It is a totally different purpose. The fire-brick lining of a blast furnace, of course, is protected more or less by the carbonaceous matter in the furnace. If the actual slag came in contact with the bricks in a blast furnace they would go very quickly. In a coke oven the bricks are heated and cooled alternately.

9049. It is something other than the high temperature?—Yes, it is something beyond the high temperature.

9050. (*Dr. Le Neve Foster.*) What is the clay, or what are the bricks which come from Belgium?—The bricks show an analysis of 82 per cent. to 84 per cent. of silica, and they are very low in alkalies. They are very well made bricks.

9051. Do you not think it would be possible, if brick-makers were to take the matter in hand, that they could make something to suit?—A great many experiments have been made so far. It does not seem as though it would do to "physic" the clay, as they call it; it does not do to add silica to a clay; you do not get the same result.

9052. You do not get the same result as if you have the silica already in it?—No.

9053. (*Mr. J. S. Dixon.*) You have given us some information about the quality of small coal and its deterioration, and the large proportion of dust, and so on. Do you think that is attributable to working the coal by coal-cutting machines—the scraping of the under-cutting being entirely dust?—I cannot answer that question. I have not known whether the small coal used has come from a seam in which coal cutters have been used or not.

9054. Then with regard to that same subject, I suppose we may take it generally that a number of inferior seams are now being worked as compared with what was the case a few years ago?—I think that is undoubted.

9055. You say that in non-recovery ovens the yield of coke is 64 per cent., and in bye-product recovery ovens 68 per cent., a difference of 4 per cent.?—Yes.

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9056. Are not these ovens practically the same?—No; the non-recovery patent oven, as it is called, has combustion going on in the upper portion of the oven, and there is a loss of coal there.

9057. That is what I wanted to ascertain in order to know how you accounted for that difference of 4 per cent.?—In the recovery oven there is no combustion whatever.

9058. Well, that will account for it. Then, as to the increase of 1s. per ton on compressed coke as compared with Beehive coke. Where was that?—That is in North Wales—both cokes going to the same consumer.

9059. I suppose from the evidence we have heard that, as a general rule, Beehive coke does fetch a larger price, compared with patent compressed coke?—In my experience it did. I do not think it does to-day.

9060. Is that for blast furnace purposes?—It is for blast furnace purposes that I am speaking now.

9061. Of course it does not make so much difference for foundries?—My experience of foundry coke is not very great. I have not had to do with foundry people; it is a small consumption.

9062. With regard to the question of lining the ovens, the previous witness told us he had greatly adopted the plan of using small bricks made in the district in place of bricks brought from abroad. Have you had any experience of that?—Yes, I have. I think the custom of buying those large special blocks from abroad is now abandoned; I do not know anyone who does it; it is the small bricks that are almost universally used.

9063. And the same thing applies to the small bricks in regard to their wearing properties?—Yes.

9064. Have you experience of that?—I have experience of the use of small bricks, and the use of small bricks as compared with blocks is very favourable. I should not think of returning to the blocks.

9065. The bricks are not produced in this country?—The bricks are not produced in this country as far as I have had experience,

9066. (*Mr. Young.*) I am not quite sure whether the point I am about to put to you has not been already dealt with, but in case it has not I should like to put it; I think you stated that about 200,000 tons of sulphate of ammonia are produced annually?—I think the quantity is somewhere about that, if my recollection serves me.

9067. Can you say how much of that is produced at gas works and how much by patent ovens?—That information is all contained in the report made by the Chief Inspector under the Alkali Act. I have not that report, but it is all divided there into gas works, coke ovens and shale works. It is all set out there.

9068. Can you say approximately (*report handed to witness*)?—It is stated in this report. This is the report for the year 1899, I am told; and it is stated here that the gas works produced 130,000 tons of sulphate, the shale works 37,000 tons, the blast furnaces 18,000 tons, and recovery ovens 11,000 tons.

(*Chairman.*) That is a total of 196,000. It is very near your figure.

9069. (*Mr. Young.*) Therefore, if the quantity was increased by 300 or 400 per cent. in the patent ovens it would not affect materially the total product?—No.

9070. I think you stated that the price had ranged from £12 per ton to £7 per ton?—In my experience I have seen it from £7 to £14.

9071. Do you know the chief reason for that difference in price?—At one time it followed nitrate of soda: a great depreciation in the nitrate of soda trade took place, and sulphate of ammonia followed.

9072. (*Chairman.*) Are they competitors?—They are.

9073. (*Mr. Young.*) And if the price was lessened, say by 25 or 30 per cent., it might to a certain extent displace nitrate?—Yes, no doubt it would; it would shut up some of the nitrate mines.

9074. Therefore, there is room and considerable margin for lessening the price, and creating a greater demand for it?—Yes, I should imagine there would be.

9075. (*Mr. Briggs.*) It is the fact that the quantity of nitrate produced is over 1,000,000 tons?—I believe it is.

9076. Therefore, as yet sulphate only bears a proportion of 10 per cent. to nitrate?—You mean in the total?

9077. Yes, the total; the sulphate made in this country only bears the proportion of 20 per cent. to the nitrate which is exported from Peru and Chili?—The ammonia contained in the sulphate is higher than that in the nitrate.

9078. Yes, ton for ton?—Yes.

9079. It would, no doubt, follow that the competition for sulphate is against the whole volume of sulphate and nitrate together really, not as against sulphate or nitrate alone?—It is for the increased consumption and the displacement of nitrate.

9080. But when you take other products the fall has been much more remarkable than in nitrate, has it not?—Yes—take tar.

9081. Or benzol?—Yes. Of course the market for benzol has been deluged. There is too much benzol produced.

9082. The putting up of the recovery ovens has brought the price of benzol down from, say 3s. to 7d., roughly speaking?—Yes, or even more than that.

9083. And, no doubt, people fear that the same effect might follow with other products?—No doubt there is an element of uncertainty in that way.

9084. When the Germans first commenced putting up these ovens they had benzol at certainly over 3s. per gallon?—Yes.

9085. And it constituted a very profitable part of the undertaking?—I think two years ago it was at that price.

9086. Not so much as that?—It was very nearly.

9087. It is cut down still further, and I suppose it is hardly worth the trouble of collection now?—Unless coal is very rich in benzol it is hardly worth it.

9088. When you speak about compression before putting the coal in, does the compressor enable you to save labour by putting in the charge in one block?—Yes, there is less manual labour.

9089. You mentioned the capital outlay necessary on the ovens to produce 1,000 tons per week. How many ovens of the Semet-Solvay type would you consider necessary for that?—About 40 ovens.

9090. You put the cost of that, roughly speaking, in round figures, at £1,000 per oven?—Yes, in round figures. Some plants are much more complete than others, and they cost more per oven.

9091. I notice that Mr. Forgie said his plant cost £120,000?—They have 100 ovens.

9092. That is more money?—Yes.

9093. £1,200 per oven, I think?—I do not know whether he included the washery in that.

9094. You do not include the washery?—No.

9095. That would mean an addition of £20,000 to your figure?—Certainly.

9096. So that before anyone could commence with a plant of this class they would have to find the washery in order to get coke?—That expenditure is necessary.

9097. An expenditure of £20,000 would be necessary to start them. Have you had experience of repairs to brickwork linings in using dry coal—unwashed coal?—I have.

9098. Have those repairs been very much less?—No, they have not. I was surprised that in using the dry coal there was not much difference in regard to the repairs, but I have noticed that in using the compressed coal, in pushing the fuel into the oven in a cake, there is a space between the fuel and the side of the oven, and there has been a material reduction in repairs.

9099. It is rather strange that the dry coal should not cause a saving in that respect?—Yes, it is strange.

9100. Were the bricks or linings of British manufacture?—They were partly British and partly Belgian.

9101. You still find the same difference in favour of the Belgian?—We still find there the same difference in favour of the Belgian brick.

9102. (*Mr. Teall.*) Is the exact composition of the clay known of which these bricks are made?—Yes; that is to say, you mean the analysis of the clay.

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Mr. J. H. Darby.

27 Jan. 1903.

9103. Cannot that be matched?—Yes. I have been able to match the clay in England with clay which seemed to me to be identical with the Belgian clay, but when made up into bricks it was not at all suitable.

9104. Does not that seem to show that there is some peculiarity in the manufacture which gives this special excellence?—So far as I know they were both manufactured in the same way or in a similar manner.

9105. (*Chairman.*) You did not test it by sending any of the clay to be made into bricks in Belgium?—No, the bricks were made in England.

9106. But Mr. Teall's question was, as I understood, whether there might not be some difference in the process of manufacture which would have been discovered if the clay had been sent there?—I was acquainted with the manufacture in Belgium, and the treatment which that clay received was almost similar.

9107. (*Mr. Teall.*) Then you think it would be due almost to some unexplained difference in the character?—Yes, in the character. I think the analysis is not a guide, or is not much guide to the ultimate result obtained.

9108. No; it depends upon some physical difference?—I believe so.

9109. (*Mr. Young.*) How was the analysis arrived at; was it an analysis made of the raw clay, or of the bricks in both cases when made up?—It was first on the raw clay, and afterwards on the burnt brick; the analysis was taken in both ways—before burning and after burning.

9110. (*Chairman.*) Did the analysis of the clay and the analysis of the brick correspond with the Belgian?—Yes, they were almost identical.

9111. (*Mr. Sopwith.*) Could you give me some idea of the measure of compression that you speak about in dealing with the compressed coal before it is put into the oven? Is it hand-stamped into boxes?—It is stamped by machinery. The box has movable sides, and the base of the box is a movable bar with a rack underneath to drive it into the oven. The fuel is let down or served into the box, and is compressed by a falling weight—a drop-hammer really.

9112. What bulk would it occupy; what would be the difference in measure; how would it be reduced?—I am afraid I cannot answer you in that way. What I do know is that the same capacity—that is, the oven capacity—holds about 20 to 25 per cent. more fuel in the compressed charge than it does with the charge that is produced in the old way.

9113. Yes, that is quite sufficient. There is one question which you answered pretty fully to the Chairman, but it was rather in a more general way—that is, with regard to the use of compressed coal and other methods which you mentioned, and that certain coals were likely to be used for coking which had not hitherto been used, and had not been considered suitable for the purpose. In your opinion generally do you think there is a large margin for the use of coals—that is to say, getting into some of the dry bituminous coals?—You mean the doubtful coals?

9114. Yes?—I know a very large plant at the present time that is being erected in consequence of the results that have been obtained by compression; the fuel available—the seams that were available—were not considered sufficiently good as coking coals to make a useful coke; but after experimenting in compressing the fuel from those seams, very large plant has been decided upon and is now in course of erection. I know that.

9115. Generally, you would consider that compression removes a good many difficulties in connection with certain coals?—Yes—what seem to be considered doubtful coals, coals on the border line between good coking coal and bad. It improves those; it will not turn into coke an absolutely non-coking coal.

9116. Have you gone into the question of natural water which is contained in the coals, interfering with their coking?—I know it does so very much; I know that the South Staffordshire coal, for instance, contains a very large percentage of water, and in that case it plays an important part.

9117. (*Mr. Brace.*) Have you had any experience in Welsh coal for coking purposes?—Do you refer to South Welsh or North Welsh coal?

9118. South?—Yes, I have.

9119. With what result?—The majority of the tests I have made are bordering on those very dry coals where it is doubtful whether there is any economy in treating those coals in a recovery oven, and unless the plant is a considerable one there certainly is not sufficient inducement to get any capitalist to face the outlay.

9120. Would there be any difference in coals coming from the Monmouthshire coalfield and the Glamorganshire coalfield?—Monmouthshire is the richer.

9121. Monmouthshire is the richer for coking purposes and bye-products?—It is richer for bye-product purposes, and as you go further West and South, my experience is that the coals get drier.

9122. You say 100 tons of coal would make 70 tons of coke?—68 tons of coke yield.

9123. If you had a bye-product attachment, would you have bye-products in addition to the yield of coke?—Yes.

9124. You were speaking about the superiority of bricks from Belgium, and about Germany practically being the home of coal-washing?—Yes.

9125. I have before me a Report in the "Colliery Guardian" for last week which states that a British firm, the Hardy Pick Company, have been supplying the washing plant to Austria after a close examination of Continental and British systems. Would you be surprised to hear that?—No, I should not be surprised. I know that the Hardy Company put up a number of coal washeries in the Pas de Calais; but, speaking generally, I think the German Feldspar Washer is the washer of to-day—I have no doubt of it in my own mind.

9126. Well, this report says that after an exhaustive inspection of coal-washing plant in Germany, France, and England, the Hardy Patent Pick Company were selected as supplying the best?—Yes.

9127. I was rather glad to see it, and I was hoping it was a sign of the times, and that we were really getting a bit of our own back. How do you obtain the prices of the bye-products? You mentioned the price of £11?—That is to-day's price for sulphate of ammonia f.o.b.; it is about that—£11 10s. or £11 12s.

9128. It is here quoted in the "Colliery Guardian" from the bye-product returns, that in London sulphate of ammonia is at £12 7s. 6d., and it has been for some weeks, I have noted. I am only trying to find out really whether these prices are right, or whether what you have quoted is right, because apparently it would make a great deal of difference?—London prices are often different to the country.

9129. London, £12 7s. 6d.; Liverpool, £12 6s. 3d. to £12 7s. 6d.; Hull, £12 5s.; Scotch ports, £12 6s. 3d. to £12 8s. 9d.?—Well, it is continually varying. That was the price which was in my mind at the time.

(*Chairman.*) Besides, one may be at the pit and the other may be at the port of shipment.

9130. (*Sir Lindsay Wood.*) I think you said that the cost of washing on washery plant was about 1½d. per ton?—On a large plant.

9131. That is to say, the plant doing washing at th rate of 100 tons per hour?—Yes.

9132. That means a largish quantity, does it not?—Yes, it is a large quantity.

9133. That is 2,200 tons per week turned into coke?—100 tons per hour, 800 tons per day.

9134. Do you think you could work plant economically with less production than that?—Yes, I do—75 to 100 tons.

9135. Is that about the size that you put up these plants for? Take the figure of 100 tons of coal washed?—That is 800 tons of washed fuel per day; but supposing the washer works five days a week, that is 4,000 tons

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per week. The ovens work seven days per week, so that that would be nearly 600 tons per day; that is about 400 tons of coke per day.

9136. Yes, between 400 and 500 tons. If you get 60 per cent. of coke out of 800 tons of coal you get 480 tons of coke?—Well, that is a large plant.

9137. But could smaller plants be worked economically?—I think from the oven point of view that 50 ovens could be worked as economically as 100 ovens—but not less than 50. But from the washer point of view I think you must go to a larger unit.

9138. (*Sir George Armytage.*) But do I not understand you to put as your figure 1,000 tons of coke per week? 1,000 tons per week was what you were speaking of?—That means about 50 ovens.

9139. Yes, but at the washing speed it is much more?—Yes.

9140. It is more than double?—Yes.

9141. (*Sir Lindsay Wood.*) 1,000 tons of coke per week would cost more than double; that is why I rather wanted to know whether smaller plant could not be worked economically?—The washing plant, I think, requires erecting (taking into consideration outlay) in larger units than the coking plant; but, of course, they must be made to fit.

9142. Then I understand from your evidence that if these bye-product ovens and patent ovens were used there would be greater economy in fuel—that is, you would get a much larger quantity of fuel per ton of coal produced throughout the country?—Yes, the product of coke made per ton would be larger.

9143. But, in addition to the product, would you get a larger quantity of coke?—Yes; it is not burnt in the ovens.

9144. But supposing it is used for other purposes, you would get 10 per cent. more coke than you are getting now?—Yes, I think you would; you certainly would get as much as 10 per cent. more, or perhaps more than that.

9145. There is great room for economy in that direction?—Yes, in that one direction—which the non-recovery patent oven gives you, practically.

9146. That is to say, the patent oven as against the present Beehive?—Yes.

9147. And the Beehive oven gives a larger proportion than the total number of ovens in use at the present time?—Yes.

9148. (*Chairman.*) I want to ask you a further question upon your evidence with regard to the bye-products, or recovery of them, as you call it. You have told us about the waste heat or spent gas from these flues being collected in a flue and passed under the boiler, and the economies which result from that. Is there any further economy by the use of such gas for power purposes?—The fuel in the oven takes about 6,000 cubic ft. per ton of gas to heat the ovens themselves, and the waste heat from the combustion of that gas is taken up in the boilers. Of the remaining amount, 4,000 ft., assuming the coal gives you 10,000 ft. per ton, is available in any direction that is required. For instance, by burning that fuel in a gas-engine you can get a large amount of power, a valuable bye-product, from the plant. Assuming that an oven takes seven tons a day—is carbonising at that rate—I make it out from the results I have obtained that each oven would be worth about 40 h.p. on the engine shaft.

9149. For the whole period that it was working?—For the whole period—the 24 hours. Of course, one oven cannot be taken by itself, but a battery of ovens coming together can be taken in that way. The gas from the coke ovens is a rich gas; it is not a gas like a producer gas or Mond gas, but it is a gas approximating to town gas.

9150. There is no difficulty with regard to control. When you speak about the town gas, you turn your tap on and you turn your tap off, but is the gas which is being continuously made under the process you have described equally under your control?—It must be disposed of.

9151. You must use it when it is made?—Yes, in some way—allow it to escape, if you cannot use it in a gas-engine, or burn it in some way.

9152. As a matter of fact, is it being used in that way in gas-engines?—It is being used, and is a very good fuel admirably adapted to the gas-engine.

9153. To what purpose is the power applied?—So far as I know it is applied to the generating current which can be used in any direction.

9154. For electric lighting or power, or both?—Electric light and power—principally power.

9155. In other words, you convert what would be otherwise waste gas or waste heat into electric energy, which might be used for either lighting or power on any part of the premises?—That is so.

9156. This would really take the place of the steam boiler?—This takes the place of the steam boilers. It can be burnt under the steam boilers, if you wish it.

9157. I am trying to see to what practical purpose you can, at a colliery, apply this power?—For instance, supposing the ovens are erected near a steel or iron-works, which is very general—there is a great demand for power of all sorts, and there is the source. It is not a gas that requires scrubbing, it is already scrubbed.

9158. Is your 40 h.p. per oven the surplus after using all the steam boilers, or is that the total?—It is the surplus after providing for the services of the coke ovens.

9159. Therefore, whether used for raising steam by passing it under the boilers, or converting it into power by means of a gas-engine, you put it that there is the equivalent value of 40 h.p. per oven?—No. It is worth about 10 h.p. per oven burnt under the boilers, or about 40 h.p. per oven in the gas engine.

9160. (*Dr. Le Neve Foster.*) Are you generating much energy in that way?—Yes, we are. We are generating a considerable amount. This plant is being put down to provide for 1,000 h.p. from the ovens themselves.

9161. (*Chairman.*) By gas-engines?—Yes.

9162. (*Sir George Armytage.*) Is this gas put into a holder or used direct?—It is used direct. It comes in large pipes, which are really holders in their way, to the gas-engines, and is used direct. If the gas-engines stop the supply of gas is wasted.

9163. Has this been applied in any way towards haulage in collieries?—I do not know. I know it is applied for pumping, but so far as haulage is concerned I am not aware of it.

9164. If there is coking plant at a colliery is there any reason why it should not be?—It is a continuous supply of power, and I see no reason why it should not be applied for hauling.

9165. And if it is put into a holder there would be no waste when there is no haulage going on?—No, there would not be any waste.

9166. You do not know of any practical appliances?—I do not know of any practical appliances as regards haulage.

9167. (*Chairman.*) Or as regards storage?—Yes, I know as regards storage. I know that at Boston, in America, where that is carried out, they store the portion they are not using.

9168. (*Mr. Sopwith.*) Does it require very large storage?—If you have a consumption of 25 cubic ft. per horse power it runs up very quickly.

9169. I mean to say, it would be rather difficult in a large colliery to have a storage power to deal with the waste gases?—You mean the coke oven working 24 hours and the pit working 10—that you want the 14 hours stored?

9170. Yes. It is difficult to put a concrete case, but generally do you think you could have storage power sufficient to deal with the gases for a colliery plant?—It is a large question. The gasworks deal with it in that way, do they not, with their holders?

9171. (*Sir George Armytage.*) May we take it in such cases, generally speaking, that the 14 hours is lost, and the gas escapes during those 14 hours?—No, because in works with which I am acquainted, where it is used, there is a consumption during the 24 hours.

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Mr. J. H. Darby.
27 Jan. 1903.

9172. For what sort of purpose?—For the general services of an iron and steelworks, for instance, pumping.

9173. And working at night?—Yes.

9174. Where there is no work at night it is practically wasted?—It must be either wasted or you must put in a gas-holder to hold it.

9175. (*Mr. Young.*) Would 1,000 h.p. not be sufficient to generate electrical energy to light up a considerable village?—Oh, yes, 1,000 h.p. is quite a considerable installation.

9176. When you are not using it at nights, do you think there is any probability of its being utilised for electric lighting?—During the day?

9177. No, at night. I understand you are using most of this energy all the day?—That is so.

9178. There is a good deal of it wasted, and in some cases at night?—Yes.

9179. You could then utilise that waste gas at night for generating electric power at night?—Yes.

9180. (*Mr. Bell*) You say that "this amount, given off in 24 hours, multiplied by 7 tons, the quantity of fuel per charge."—Per charge per oven.

9181. That is really per day?—Yes, per day.

9182. I thought the Beehive coke ovens required about 60 hours to burn out?—Yes, two charges in a week is the usual practice with the Beehive ovens.

9183. You are speaking of the recovery ovens?—Yes.

Mr. THOMAS Y. GREENER, called; and Examined.

9184. SUMMARY OF EVIDENCE.

Mr. T. Y. Greener.
27 Jan. 1903.

(1.) I am a mining engineer, and have the general management of the collieries belonging to Pease and Partners, Limited, in the County of Durham, together with the coking establishments attached to each pit. Those establishments consist of 1,864 ovens of various descriptions, with all necessary plant for washing, disintegrating, and storing coal, and for conveying it to the ovens to be converted into coke.

(2.) Last year 1,046,420 tons of coal were carbonised, and there were produced therefrom 692,837 tons of coke, equal to an average yield of 66·2 per cent. of the coal used.

(3.) When all the cokeyards are in full operation about 1,133,000 tons of coal are carbonised per year, and the output of coke is 750,003 tons.

(4.) Some of the coal from the best seams is coked after disintegration, practically as it comes out of the pit, without washing or elaborate cleaning, whilst other coal, from inferior and dirty seams, is most carefully treated on picking belts and screens, and in some cases the whole produce, and in others the small only is washed. Both systems are in operation at the collieries under my charge; the latter, however, is usually adopted at those pits in which the round coal is sold for steam, household, or other purposes, and the small only is made into coke.

(5.) With regard to the first point on which the Commission desire me to speak, viz.:—

"Cleaning inferior kinds of coal by washing processes and so rendering them marketable or fit for use."

I may say that there are in daily use at one or other of the Pease's West pits, two Robinson's washers, each capable of washing 40 tons per hour—three capable of washing 25 tons per hour, and one Shepherd's machine capable of washing 25 tons per hour. The Robinson washer consists of a pan, conical in shape, standing on the small end, into which water is admitted from the bottom under a pressure of 10 to 15 lbs. per square inch. The coal enters at the top, and after mixing with the water is kept in a state of agitation by arms constantly revolving for the purpose. Owing to the difference in the specific gravities of coal and dirt the former rises to the top, and is carried forward with the water and conveyed to the storage hopper, whilst the latter falls to the bottom of the pan, and is discharged by means of a slide into dirt wagons or elsewhere. I am using these washers for coking coals only, and in some instances the coal is washed just as it comes out of the pit; in others it is first disintegrated to powder. The results, however, are practically the same in both cases, and the percentage of dirt washed out, ascertained over a long period, varies at different pits from 4½ to 9½ per cent.

It was thought before the attempt was made that it would not be practicable to wash disintegrated coal, but, as a matter of fact, no difficulty is experienced.

The Robinson washer and others in which coal of various sizes is indiscriminately washed together, are, however, all more or less wasteful by reason of the percentage of coal the dirt must necessarily contain if coal absolutely free from removable dirt is to be guaranteed. The efficiency of such washers depends entirely upon the care, attention, and experience of the attendant; he may, on the one hand, conduct the washing in such manner that the free dirt is not removed from the coal, whilst, on the other hand, he may so arrange that the coal is absolutely clean, but that there is an enormous wastage of good coal in the dirt. It is not unusual to find that the dirt from washers of the class to which I am alluding contains from 5 to 34½ per cent. and even more of good coal; hence, to my mind, efficient and economical washing can only be obtained in those systems such as the Coppée, Luhrig, and others of that type in which the coal is first separated into several different grades, and each grade or different size is washed by itself. Under those conditions coal practically free from removable dirt, and dirt which does not contain more than 2 to 3 per cent. of free coal, can be guaranteed.

At the present time I am erecting a Coppée washery to wash 100 tons per hour of coking coal, and I am confidently expecting not only to obtain clean coal, but clean dirt, and I feel sure that in the future this class of washery will entirely supersede the rough and ready washing processes many collieries have adopted during the past ten or twelve years.

(6.) MANUFACTURE OF COKE.

(*a.*) Coke Ovens Without Utilisation of Gases.

The manufacture of coke by methods in which no use whatever is made of the gases given off in the process of coking is most wasteful and extravagant. The system is however, still extensively adopted in the north and other parts of England, though during the last few years the waste gases have been more or less applied to useful purposes at most coking colleries.

The class of oven almost universally employed is the ordinary Beehive, 11ft. in diameter.

The oven is usually loaded with 6½ tons of coal very finely ground, which requires 72 hours to burn off, and may yield in Durham 60 to 62 per cent. of the charge—say, 3·9 to 4·1 tons of coke. Such an oven will carbonise 13 tons of coal, and will manufacture rather over 8 tons of coke per week, and if built of suitable fireclay material may be expected to continue in operation 20 years or more, with very little repair. I have many such ovens working which were built more than 50 years ago, and which so far as it is possible to judge have not been completely rebuilt since they were originally erected. The extreme simplicity of the oven and its durability, coupled with the hard dense coke it produces of bright silvery appearance, doubtless account for the popular favour it enjoys, notwithstanding the waste of coke that occurs in the process of burning. That waste is occasioned by the system of admitting the air through holes in the door of the oven directly on the charge.

I am not aware that a larger yield of coke than 64 per cent. of the coal carbonised is being obtained, even under the best conditions, at any yard in this county from the ordinary Beehive oven without flues of any description, and, therefore, the waste of coke alone must vary according to the quality of the coal from 10 to 16 per cent. of the possible yield. The usual practice is to build the ovens in double rows back to back, and to construct a flue between the rows for conveying the waste flame and gas to chimneys provided for the pur-

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pose for each 20 or 24 ovens. Square or oblong ovens of similar construction to the Beehive are in use at many yards, they do not waste quite so much coke in the process of burning owing to their greater capacity and larger charges of coal coked at one time; hence the yield is perhaps 2 or 3 per cent. better than that of the 11ft. Beehive. The same result, however, is obtained by increasing the size of the latter oven to 12ft. or 12ft. 6in. in diameter. There is a limit beyond which it is not practicable to increase the size of ovens of this description, and that limit is found in practice to be a capacity to contain about 7 tons of coke.

If I am not travelling outside the scope of the points on which you wish me ito give information I should like to refer to various classes of ovens constructed with flues in which the gases are utilised for heating the ovens themselves, and so increasing their output and efficiency.

I attach hereto plan of the Beehive underflue oven, designed by Mr. Robert Dixon, for many years manager of the coke works here; 618 of such ovens are in daily operation in one or other of the cokeyards under my charge, and you will observe, on referring to the plan, that a series of eight flues are constructed underneath the oven bottom, through which the flame and hot gas are coursed before being discharged into the waste gas flue. The effect of that arrangement is to cause coking to proceed upwards and downwards, hence the time occupied in converting a charge of coal into coke is reduced fully one-third.

The underflue oven, 11ft. diameter, therefore carbonises 18 tons of coal per week, and manufactures 12 tons of coke, and has an efficiency, ascertained over a long period, varying from 65 to 70 per cent. of the coal used. This type of oven, notwithstanding its undoubted merits, has not been adopted elsewhere chiefly because the columnar structure of the coke is to some extent destroyed—the effect of the upward and downward process of coking is to create a parting in the column of coke perhaps 12in. to 14in. from the bottom, hence that portion is heavy, and in shape not unlike an elephant's foot. Other manufacturers, however, have introduced ovens with flues round the dome, through which the air to support combustion is admitted after being heated, hence the general efficiency is quite equal to that of the ovens I have just described, whilst the structure of the coke is not altered.

Mention should be made of the retort ovens like the Coppée, which are in operation in this district, not for the purpose of obtaining bye-products, but simply for the sake of the greater yield of coke they produce by reason of the fact that the heat from the gases is to a large extent utilised by means of a series of vertical flues for rapidly converting the charge into coke. No air is admitted into the combustion chamber of the oven, and, therefore, practically laboratory results should be realised.

A small battery of Bauer ovens has lately been installed at one of the cokeyards under my charge; those ovens are 39ft. long, 7ft. 6in. high, and 20in. wide; they are charged with 9½ tons of fi ely ground coal, and as a rule produce rather more than 7 tons of good coke each 36 hours—hence their output is about 33 tons of coke per week per oven, and their yield per cent. varies from 75 to 80 per cent. of the coal carbonised. These results are obtained entirely by coursing the hot gases and flame through a series of vertical flues in the side walls over the top and under the floor of the oven, hence the charge of coal is surrounded on all sides except the two ends with flame. I think, therefore, I have shown that whilst in the various ovens I have been describing the hot gases are not used for heating steam boilers, yet they are not by any means wasted, but are made a source of advantage and profit by increasing materially the output and percentage yield of the oven.

(*b.*) Coke Ovens with Gases utilised for Heating Steam Boilers.

The application of coke oven gases to firing steam boilers is a very simple matter, and at the same time a most economical method of raising steam; it is not economical in the sense that the theoretical quantity of water is evaporated per pound of coal carbonised, but it is certainly economical having regard to the fact that a valuable product is utilised which would otherwise be wasted. Thirty-two boilers of various descriptions are fired bv coke oven heat at the collieries with which I am connected, with the result that the coal used for boilers other than those on the ovens does not exceed 1·23 per cent. of the total production of the pits, which is 1½ million tons of coal per year. I know many collieries at which fully 5 per cent. of the output is burnt at the boilers, and such a consumption is rather under than over the usual average.

The boilers attached to the ovens at the Pease's West Pits are of the following descriptions:—

24 Double-flue Lancashire boilers, 30 ft. by 7 ft. 6 in., and some 28 ft. by 7 ft.

5 Water-tube boilers (Babcock and Wilcox).

3 Egg-ends, 28 ft. by 3 ft.

The Egg-ends may be disregarded; they will be replaced by others of better and more efficient design very shortly. The heat from 676 ovens is conveyed in flues having, generally speaking, an area from 15ft. at the small end—that is the end furthest from the boilers—to 30ft. or 36ft. next the boilers themselves, and not less than 13 ovens per boiler are in any case applied. That number, however, is the minimum number of ovens of the same capacity as the ordinary Beehive, 11ft. diameter, which can be satisfactorily attached to ensure even moderate results from boilers, and as a rule not less than 20 to 25, 11ft. Beehive ovens should be applied to each Lancashire boiler 30ft. by 7ft. There is considerable variation in the results obtained in different yards from boilers on the ovens, but on an average about 1½lbs. of water per hour are evaporated per pound of coal carbonised in the ovens attached to the boilers.

The Pease's West coal will evaporate 7lbs. of water per hour per pound of coal when carefully burnt in a hand-fired Lancashire boiler, hence the efficiency of the coke oven boilers is to my mind quite satisfactory.

It follows from the figures I have quoted that in order to generate a given quantity of steam there must be a larger number of boilers fired by coke oven heat than would be necessary if those boilers were hand fired, and therefore the owner of a coking colliery must be prepared to purchase at least four times as many boilers as he would require if they were hand fired. The saving in coal is, however, well worth the additional outlay. If the main flues and chimney are properly proportioned to the work they have to do, the burning of the ovens is not in the least retarded, and their efficiency is therefore not impaired.

I am of opinion, from the experience I have had, that the Babcock is the best coke oven boiler, because it offers less resistance than any other boiler with which I am acquainted to the passage of gases from the ovens to the chimney, and therefore does not interfere with the free burning of the oven, whilst at the same time it presents a larger heating surface in proportion to its capacity than boilers of other makes; the nearest approach to it is the five-flue boiler, of similar design to the Lancashire, about 8ft. to 9ft. 6in. in diameter. A chimney capable of producing 1in. W.G. is required to draw off the gases from 60 ovens attached to a flue 150 yards long, and its area ought not to be less than 80ft.

The efficiency of coke oven boilers is largely increased if good water heaters are applied, and under those conditions it would not be requisite to have four times the number of hand-fired boilers required for the same work; probably not more than one additional boiler in four would be wanted.

(*c.*) Coke Ovens with Recovery of Bye-products.

One hundred and eight of such ovens of the Simon-Carvès type have been in operation since 1881 at the Bankfoot Coke Works, near Crook, and were the first of that class of oven to be introduced into this country; they are therefore much smaller than those of more recent construction, and do not possess the latest improvements. They are built in batteries containing 25 or 30 ovens each, and are placed at a distance from each other of 3ft. 5in. from centre to centre. The ovens consist of a rectangular chamber 23ft. long, 6ft. 6in. high, having a width of 19⅝in. Underneath the bottom of the chamber a gas flue is constructed, into which the gas from the chemical works is returned after having given up its by-products. The centre wall separating

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Mr. T. Y. Greener.

27 Jan. 1903.

each oven contains a series of horizontal flues common to two adjoining ovens, along which the gas is coursed for heating the side of the coking chamber. Each oven is charged with finely crushed coal, either compressed or uncompressed; if the charge is uncompressed it weighs 4 tons 6 cwts., and yields about 3 tons 3 cwts. of coke, equal to 73 per cent. of the coal carbonised. If compressed coal is being coked, the charge weighs about 4 tons 13 cwts., and yields about 78 per cent. of coke, say 3 tons 12 cwts. The time occupied in coking charges of compressed and uncompressed coal is respectively about 72 and 55 to 60 hours. It would probably be more strictly accurate to state that the above are the intervals between each discharge of the ovens. The single shift is in operation, hence it frequently happens that an oven is not drawn for it may be seven or eight hours after the charge is completely coked because it was not ready during working hours; hence it follows that a greater output and a greater percentage yield would be obtained if the ovens were worked continuously 24 hours per day. It does not, however, by any means follow that the results would pay for the increased cost.

The quality of the coke from the Simon-Carvès ovens is, generally speaking, good, and its mechanical condition exceedingly hard and dense; hence the coke is suitable for foundry and blast furnace purposes, and finds a ready sale for each. Its appearance is not so bright as that of the Beehive coke, owing to its being cooled on the benches, but in other respects it is quite as good and serviceable. The effect of compressing the charge, the most recent development in the manufacture of coke, is to increase the output of each oven and of good coke, whilst at the same time it improves its density and hardness, and reduces the quantity of breeze and ballast produced. The great difference in principle between the retort or bye-product oven and ovens of the Beehive type lies in the fact that in the former the coal is carbonised in a chamber hermetically sealed, from which all air is as far as possible excluded, and the coking process is carried on by heat from gases conveyed along flues completely surrounding the oven except at the ends, whilst in the Beehive and ovens of that class the coal is coked by the heat of its own combustion, and therefore more or less waste is bound to take place; hence, apart from the value of the bye-products, the retort oven is more efficient than any other type of oven.

With regard to the different classes of retort ovens, they may be divided into two—those in which the flues are horizontal, as in the Simon-Carvès and Semet-Solvay, and those in which the flues are vertical, as in the Bauer and all descriptions of the Otto ovens. I think, however, it is almost generally held that ovens in which the flues are vertical have established their superiority over those in which the flues are horizontal. I have no doubt, however, that competent authorities will be found who will take exactly the opposite view to that I have expressed, and therefore I hesitate to be dogmatic on the point.

The method of obtaining bye-products from the gases given off by the coal in the process of coking is very simple, and the treatment is similar to that adopted in gas works.

The gas from the oven chamber is drawn off by exhauster engines, passed through a serpentine in which the tar is deposited and stored in tanks, then washed in scrubbers till the liquor is a given strength, and finally passed through creosote oil before it returns to the ovens. When the gas reaches the oven it enters the bottom flue, and sufficient air is admitted for complete combustion; the flame then travels through the various flues of the oven, and at length reaches the main gas flue, and is conveyed under two Babcock and Wilcox and three egg-end boilers before being finally discharged into the air, hence it has been used first to obtain bye-products, second for coking the coal, and third for steam raising.

The bye-products manufactured at the Bankfoot Works are tar, pitch, benzol, sulphate of ammonia, and the various oils given off in the distillation of tar. The production of each from the installation of Simon-Carvès ovens in operation is not equal to the results obtained from more recent and improved plants, and it would be unreasonable to expect it from ovens which have been in every day use since 1881. As a rule, however, the following quantities of the undermentioned bye-products are obtained:—

Tar - - - - -	3·61 gallons	Per ton of coal coked.
Ammoniacal Liquor	32·28 „	
Sulphate of Ammonia	14·74 lbs.	

Pitch, about 1,100 to 1,150 tons per year.

There cannot, I think, be a doubt that the use of bye-product ovens will be immensely extended in this country during the next few years; indeed, large installations have lately been built, and others are in course of construction.

Processes for making Coke out of Coal usually considered Non-Coking.

So far as I am aware there is no process in operation by which non-coking coals can be converted into coking coals. Several attempts have been made to manufacture coke out of such coals by the addition of pitch, tar, or other bituminous matter, but they have never been successful, at all events from the commercial point of view.

Manufacture of Briquettes.

I have had no experience whatever in this matter, I do not therefore know anything of the subject practically. I am not aware that briquettes are now being manufactured in the North of England.

9184.* (*Chairman.*) Is there any particular kind of washer which your experience leads you to the conclusion is better than others?—There is no doubt to my mind that the best washers are those of what I might call the Luhrig type, in which the coal is first sized and then washed and cleaned. Each grade or each size of coal is washed separately. Of course, there are many types of that class of machine, such as the Luhrig, the Coppée, the Baum, and the Humboldt—all those are washers of that type.

9185. Are these machines in their operation more or less automatic?—Yes, they are all more or less automatic.

9186. You begin presumably with coal which is less than the ordinary sale coal?—Well, at a coking colliery it does not follow that you do. At collieries such as ours, where the whole produce is practically used for coking, the coal as it comes out of the pit is, generally speaking, first of all put over a jigging screen, and there it is separated roughly into round and small. The round coal is then passed on to revolving screens, and it is separated again into nuts and dead small.

9187. Is the round coal disintegrated when used for the purpose of coking?—Yes.

9188. All of it?—Yes.

9189. Then the separation is for the purpose of——?—Of cleaning, and also for the purpose of saving disintegration. There is no need, for instance, to disintegrate the dead small.

9190. Therefore you would not pass that through the disintegrator?—Not in all cases. Sometimes it is convenient to pass it through, and in that case we do pass it through, and in other cases, where the disintegrators are perhaps of limited capacity as compared with the output, we pass the round and the nuts through the disintegrators.

9191. I observe you say that some of it is used for making into coke as it comes out of the pit?—Yes, I mean it is passed straight to the disintegrators as it comes out of the pit without washing or without cleaning of any elaborate description.

9192. Is that for the purpose of economy of time?—No; that is because the coal does not need any special amount of cleaning. It is economy in cost, not economy in time.

9193. It does not mean that you make good by the additional quantity of the large coal the inferiority of the small by reason of the larger percentage of the dirt and so on that would be washed out of the small?—No, it is that the coal is of one uniform quality, and practically free from dirt.

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9194. Is there much difference in the percentage obtained whether washed or unwashed?—Well, it depends upon how you look at it.

9195. You have partly answered the question. I admit I had taken it rather differently, because you say, as I understand, that the coal that is not washed is not washed because it is cleaner?—Yes.

9196. And the washing therefore is not necessary for the purpose of separating the dirt?—That is so.

9197. That being so, supposing the coals were the same as regards quality, but one contained more dirt than the other, the product would be the same, because the dirt that is washed out of the one did not exist in the other?—Take it in this way: at collieries in which the coal is washed, probably the percentage of coke realised might be 60 per cent., that is on the gross output, assuming that we washed out 8 or 9 per cent. of dirt. If the yield of coke is calculated upon the net produce, that is to say, after deducting the dirt, the percentage of coke is probably 66 or 68.

9198. Does the water absorbed in the process of washing interfere with the coking process?—Well, it would certainly, assuming that the coal were put into the oven containing, say, 50 per cent. of water.

9199. But it has passed through some process to enable it to be dried before being used for coking?—It is generally stored in large hoppers. As a rule, we have storage capacity for two days' oven requirements; so that the coal which is washed to-day is used to-morrow, and it has therefore 24 hours to drain.

9200. And within that period of time you get rid of as much water as is necessary?—Well, the coal goes into the oven containing from 10 to 20 per cent. of moisture.

9201. Is the kind of oven used mainly the Beehive, or both kinds?—Out of the total number of ovens that we have at the various collieries by far the larger portion are Beehive ovens. They are not necessarily Beehive ovens without flues of any description, but they are ovens in that shape, most of them.

9202. At the present time you say you are erecting a Coppée washery?—Yes.

9203. That is to wash 100 tons per hour of coke and coal?—Yes.

9204. You have some experience as regards the coal still remaining in the dirt that is washed out by the ordinary method. Do you anticipate that you will ever get what you call clean dirt, that is to say, dirt free from coal?—No; we do not expect to get dirt containing less than about 2 per cent. of coal.

9205. You think you can get it down to that?—Oh, yes, I am quite sure we shall.

9906. In the manufacture of coke, are the gases from the coke ovens utilised?—In some coke ovens, yes; in others, no.

9207. For what purpose are they utilised?—At the collieries with which I am acquainted we use the gases from the ovens for heating boilers, for heating the ovens themselves, and for obtaining bye-products.

9208. Any used for power purposes?—No, other than the raising of steam.

9209. Not direct by gas-engines?—No; that is a matter we have under consideration at the present time in connection with the application of the waste gases.

9210. There are instances in your district of Middlesbrough of blast-furnaces and so on where they utilise the gas for power purposes?—There is no instance of which I am aware in which gas is used directly in gas-engines.

9211. Is that the case on the Continent?—I have seen gas-engines applied in Germany.

9212. Successfully?—Yes.

9213. Is there any difficulty with regard to these patent ovens in reference to the repairs of them, or the maintenance of them?—Oh, yes, there is a very considerable difficulty. There is not very much difficulty in the Simon-Carvès ovens we have, but in the retort ovens which are now being put up, and in which the heat is much greater, there is difficulty in finding fire-clay material to stand the heat.

9214. Are they built of bricks made at home, or bricks made abroad?—The last battery of ovens that we erected, which were Von Bauer's patent, were built of German bricks.

9215. We have had some evidence this morning about Belgian bricks and German bricks, and it is said that in some of the ovens it is found extremely difficult to get any bricks in this country which will stand?—Those I might mention came from Oberbris. We went to Germany because we were not sure that we could find bricks in England to stand. There was another reason, and that was because the patentee recommended that we should use German bricks.

9216. And you preferred not to give him any excuse?—Quite so.

9217. Have you had to replace any of them?—We have had to rebuild the main gas flue, but that main gas flue was built of our own bricks.

9218. I am afraid that does not help us much. That rather goes to show that your bricks had not stood as well as the others?—Yes, that is so.

9219. Have you any knowledge yourself why it is we cannot get them here?—Well, I rather think we can. We make fire-bricks at Pease and Partners very largely, and we are now trying a brick in which there would be two-thirds of gannister to one-third of fire-clay, and we think a brick of that description will stand equally as well as the German bricks.

9220. Do you attribute it to the variation in temperature, or the high temperature, or both?—In the first place it is the high temperature; but it is also largely due to the mechanical condition of the German brick. It is a brick that is free from potash and soda—at least it is very largely free from them. I am only speaking from memory, but I think Mr. Stock, the analytical chemist whom we generally employ in Darlington, told me that any brick containing 2 or 2½ per cent. of soda or potash would not stand the temperature of the retort oven.

9221. You think it is the high temperature which makes our bricks give way, rather than the variation and the sudden changes?—There is very little variation in temperature of the retort ovens. When I say very little I mean there is very little variation as compared with the variation in the Beehive oven, because the retort oven is discharged by a ram red-hot, and it should be practically filled within the next ten minutes or quarter of an hour, so that the oven itself does not vary very greatly in temperature.

9222. Is the maximum temperature in the Beehive as high as in the retort?—Yes, I should think it is higher.

9223. I observe that, in your opinion, it is not a mere question of what is called the Beehive, it is rather the shape and the general construction, is it not, that affects the question?—The Beehive is the oven that has been most generally used in the north, and so long as we had the very best coals that oven was perfectly satisfactory; but now that we are making coke from what are described as leaner coals, the oblong or square oven is rather better.

9224. You are now speaking of non-recovery?—Yes.

9225. Does your coal which is used for this purpose adapt itself to the recovery process?—Yes.

9226. It is not very rich?—No; it is a coal which contains probably 23 to 27 per cent. of volatile matter.

9227. In that case it is more economical to make coke by the retort oven than by the Beehive?—Well, I do not know why you should say "in that case."

9228. Well, I will put it this way: the evidence we have had leads at all events to this conclusion, that the richer the coal the more advantage there is in adopting the process which enables the recovery of the bye-product?—Yes, that follows.

9229. And that in the case of the richer coals you not only get a larger product per ton of coal, but you get a larger value by reason of the bye-products?—Yes.

9230. Now you speak about various classes of oven constructed with flues in which the gases are utilised for heating the ovens themselves, and so increasing the output and efficiency. You have a plan, I think, which illustrates this?—Yes, I have one. (*The Witness explained the plan to the Commissioners.*)

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Mr. T. Y. Greener.

27 Jan. 1903.

9231. Would you tell us generally about the more modern practice? Supposing you were going to put down a large plant for coking in your district now, would you adopt the retort oven?—I think undoubtedly I should do that, and Pease and Partners I have, no doubt would do it.

9232. Therefore, may we take it that, with all their advantages, the Beehive oven is not the system that would be adopted to-day on a large scale?—I think so. It is very difficult to express a general opinion upon a point of that sort, because there is a very great deal of prejudice still existing with regard to a retort oven coke.

9233. Do you think it is "prejudice"?—I should say yes.

9234. Do you think that chemical tests—analyses and so on, would reveal that the one coke is as good as the other?—So far as the analysis of coke is concerned undoubtedly it is precisely the same, but it is the mechanical condition of the coke that is different.

9235. (*Professor Dixon.*) Is there much difference in the hardness?—Not with the best coal. With the best coal the Simon-Carvès coke is quite as hard as the Beehive coke.

9236. Have you had anything to do with the Semet-Solway?—No.

9237. (*Chairman.*) Does the greater use that you get out of the Beehive oven, as you described to us just now, by which you get the products out once in 48 hours instead of once in 72 hours, involve any additional fuel?—It involves additional fuel in the sense that there is more coal carbonised.

9238. But the waste gases, as I understand, are used in aid at all events of, if not in substitution for, fuel?—They are used to hasten the coking process, and after hastening the coking process are collected in a waste flue, and are then conveyed under boilers.

9239. But the boilers are presumably not worked the whole 24 hours—the coke ovens are. The manufacture of the gas goes on all the time. What happens to it when it is not being utilised?—It is always being more or less utilised.

9240. Night and day?—Yes; because, although it is quite true that the steam consumption at night in most collieries is not so large as it is in the day, still there is the ventilation of the colliery and, as a rule, pumping and frequently at most of our collieries there is electric lighting or electricity used for power purposes; so that the boilers are always generating steam which is being effectively applied.

9241. I see you speak about a battery of Bauer ovens which have lately been installed, and which take a charge of 9½ tons; that is rather a large quantity?—That is very much larger than any other ovens we have.

9242. Does that lead to economy?—Yes.

9243. (*Professor Dixon.*) How many ovens are there?—Twelve. They were put up as an experimental battery, with the intention, if they turned out well, of enlarging them.

9244. (*Chairman.*) You have quite a large number of steam boilers at this place?—Yes, we have a large number of boilers.

9245. You speak of 24 double flue Lancashire boilers?—I do not mean that they are all together. The largest number of boilers that we have in one row attached to coke ovens is probably five.

9246. This number relates to boilers which are fired by the waste gases?—Yes.

9247. What is the effect upon the life of the boiler. Is it better or worse than hand-fired coal?—Well, theoretically it ought to be better. It is only about 10 or perhaps 12 years ago that we first began to put boilers on the ovens.

9248. They have not given way yet?—No.

9249. What is the Babcock and Wilcox boiler that you speak of as being the best coke oven boiler. Is that because you can utilise the gases better?—The reason I say the Babcock and Wilcox boiler is the best coke oven boiler is that it affords the least resistance to the passage of the gases through the boiler itself. In the case of the Lancashire boiler we have to course the gases back again, and finally get them into the chimney. In the case of the Babcock they are brought straight into the boiler itself, and there is merely one baffle-plate, which changes the course of the current and gives it an upward motion.

9250. How many lbs. of water per ton of coal do you reckon?—The most we have ever done seems to be about two lbs. of water per lb. of coal carbonised; but we do not average that—1½ lbs. is more about the average.

9251. Would that be the same hand fired as boiler fired?—No, if you hand fire the boiler you ought to get 7 lbs.

9252. In one case you use the whole; in the other only residue?—The oven boiler is not like a hand fired boiler. Supposing there are 40 Beehive ovens attached to a couple of Lancashire boilers, one-third of those ovens have to be drawn every day, and during the process of drawing there is a very large admission of cool air, which cools the gases and the hot air very considerably.

9253. Then with regard to the coke oven and the recovery of bye-products. You have quite a number of these ovens, I understand?—We have 108 of the Simon-Carvès type.

9254. Have you any comparison of the product per ton of coal from these ovens compared with ovens of the Beehive type?—With our Simon-Carvès practically we only get about 7 or 8 tons of coke a week, very much the same as we do out of the Beehive oven, but that is owing to the size of the oven.

9255. (*Mr. J. S. Dixon.*) The Chairman means the proportion of coke per ton of coal?—The proportion of coke is at least 10 per cent. better in the Simon-Carvès oven than it is in the Beehive oven.

9256. Would you say that the figure of 10 per cent. would be generally applicable as between the two classes?—I should say that is rather a low figure—it is nearer 13 per cent.

9257. Do you compress any of the coal for coking?—Yes.

9258. Is that a process which is extending?—Undoubtedly.

9259. You think favourably of it?—Yes.

9260. Does it improve the quality?—It improves the condition of the coke.

9261. Makes it of better saleable value?—Yes, harder and denser, and therefore it will carry more weight.

9262. (*Professor Dixon.*) Are you compsessing it in the retort?—In the chamber outside the retort, and then push it in.

9263. (*Chairman.*) It is all ground up first?—Yes, it is ground to powder.

9264. How often do you get the retort ovens empty?—About every 72 hours. We could empty them oftener, but we only work single shift. Our shift is over about 2 o'clock in the day; if, therefore, an oven comes off at 3 o'clock, say, it must remain in until the next morning at 5 o'clock, and to that extent, of course, it is wasting.

9265. It does not do any harm to the coke?—It wastes it.

9266. Have you gone into the question as to whether coal which is naturally considered uncoking can by any process be converted into coking coal?—I do not quite understand what is meant by that. If is meant, for instance, anthracite coal, there are no means possible of converting anthractite into coke, because it is very nearly pure carbon to begin with. If you mean a coal that is leaner than the best coals, then such coal would be very finely ground to dust, and would be compressed and coked in a retort oven, but if it would not make coke under those conditions it would not make coke at all without, it might be, the addition of bituminous matter.

9267. There is a border line where coal either ceases to be coal available for coking, or where it begins to be?—Yes, that is perfectly true. You can have two coals, one of which would not make coke and the other of which would make coke.

9268. And some of it due to the fact that it is lean?—Yes.

9269. We have had some evidence which rather tended in this direction—and I think your own evidence does—that compressing such coal is an advantage?—Oh, clearly so.

9270. Have you any experience of the manufacture of briquettes?—None whatever.

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9271. (*Sir Lindsay Wood.*) I think you said you were using the Robinson washer?—Yes.

9272. But you prefer the other?—We use the Robinson washer because we investigated the other washers of the same class as Robinson's—I mean washers in which the coal is washed in bulk all sizes together—and it seemed from our investigation that Robinson's was as good as any of the others.

9273. Of that character?—Yes.

9274. It is much cheaper to erect than the Luhrig?—Yes, than the Luhrig or the Coppée.

9275. I suppose that is one advantage. You say here that the loss might be from 5 to 34½ per cent., and even more?—Yes; I have figures which show it, but I do not know whether I should be justified in disclosing them to the Commission. I can tell you how I got them: when we were considering the question of putting up the Coppée washer I saw most of the other washers working in different parts of the country, and I took myself samples of the dirt coming away from those washers, and had them analysed to ascertain the percentage of coal there was in the dirt, and I have the results here. I have one, 20·9; another, 2·6; another, 34½; another, 19·9; and another, 5·2.

9276. (*Chairman.*) That is coal in the dirt?—Yes.

9277. (*Sir Lindsay Wood.*) All depending upon the man who is working the machine?—Yes.

9278. In the other it is not so dependent upon the man's labour?—No, it is not, because the valves are fixed for each different class of coal; that is to say, at each different colliery the outlet valve has to be fixed and I have no doubt there is waste of coal until the right position exactly for that valve is found; but once it is found, there should be no further waste.

9279. Do you prefer the Beehive oven with the flues underneath?—No; I think the recovery oven is the best.

9280. Taking cost and everything else into consideration?—Yes; the first cost is very much more, but it repays itself very quickly.

9281. To what extent is it more?—An up-to-date bye-product oven would probably cost with its proportion of recovery plant £500 per oven.

9282. One witness I think gave us it as £1,000, including washing?—Yes, with washing; but I was not including washing.

9283. That is the oven itself?—Yes. I think you can get makers who would go very much below £1,000.

9284. (*Chairman.*) Mr. Forgie also gave us figures which indicated that the difference in cost between the two systems would be more than saved in two years?—Yes, I daresay that might be so.

9285. (*Sir Lindsay Wood.*) Do you think that there is likely to be any great advance in coking so as to produce more coke out of a ton of coal than what we now get?—I do not think there can be very much improvement in coking in the sense of increase in the yield, because practically the retort oven will give the laboratory result. Some of the patantees claim that they not only give that, but they will give 4 to 5 per cent. more, because they say that they recover a certain part of the carbon that would be carried away in the volatile hydrocarbon. Dr. Von Bauer says that.

9286. It is only a question of getting people to spend the money to put the best coke oven up?—Yes, and to overcome the prejudice no doubt against the coke.

9287. On that point have you any means of knowing what is the proportion of coke made by the two processes?—No, I do not know; but I should think that the ironmasters in Middlesbrough would have experience of that. The majority of the coke used now in the furnaces is retort oven coke. Samuelson's make all their own coke in that class of oven; Bell Brothers make their own coke; the North-Eastern Steel Works make their own coke in retort ovens; and the Weardale are now putting up an installation of ovens, and Bolckow-Vaughan's are also doing so.

9288. This points clearly to this—that all the large concerns putting down modern plant adopt this retort oven?—I think there cannot be a doubt in the mind of anyone who has investigated the subject at all that the modern retort oven, even if it is many times the cost of the Beehive oven, is very much cheaper in the end.

9289. And therefore it would prevail in the long run?—Yes.

9290. (*Mr. Bell.*) Are these retort ovens put up at Middlesbrough all for the recovery of bye-products?—Yes.

9291. (*Professor Dixon.*) You have had most experience with the Simon-Carvès?—Yes.

9292. In your judgement is that the best process now being worked?—Oh, dear me, no.

9293. What do you think is the best?—Well, personally I prefer the Otto-Hilgenstock. I do not know that I put them absolutely as the best.

9294. Have you those ovens at work?—No, I have not. We are considering the matter now, and I have not made any definite recommendation to my directors upon the point, therefore I have to some extent an open mind. But ovens of that type are better certainly than the Simon-Carvès.

9295. Are those long rectangular ovens?—Yes.

9296. As to your experience of the coke made in the Simon-Carvès, is that now as hard, and will it stand crush, as well in a blast furnace, for instance, as that made in a Beehive?—Yes; I should think it would stand it better if made from compressed coal.

9297. And it has a silvery lustre?—No, it has not a silvery lustre; the appearance of the coke is against it.

9298. You have not brought any specimens, I suppose?—No, but I would have if I had known that you wanted them.

9299. You can get pieces of Simon-Carvès coke with a lustre?—Yes, you can get it. If you speak of odd pieces probably it would be so, but taking the general appearance of the bulk of the coke it is not nearly as pretty as that of the Beehive.

9300. It is not formed in long columns?—It is not a column at all.

9301. There is some prejudice with regard to the shape?—Oh, yes, there is great prejudice, excepting with people who make it for their own use.

9302. Do you consider there is less loss in drawing it from the Simon-Carvès for instance, than drawing it from the Beehive ovens?—There must of necessity be less loss in drawing with a ram than by hand.

9303. You finish it quickly?—Yes. When you said "less loss" I thought you meant less percentage of breeze and small made.

9304. I mean less loss in quenching?—Yes; it takes about 20 minutes to cool a Beehive oven, and about 20 minutes to cool a retort oven.

9305. There is no great difference, then?—No, there is no great difference. I do not know whether the time could be reduced by using a hood.

9306. (*Mr. Sopwith.*) What was the amount of compression that you employed?—10 per cent.

9307. Is that carried to the greatest extent?—We have not tested it.

9308. You have not tested whether you could carry it further?—No, we have not tested whether we could carry it further, but the coke is sufficiently dense; in fact, an ironmaster told me there was a chance now of making coke too dense. I did not think that was possible.

9309. Practically what is done appears to be about the proper limit?—Yes, I think so.

9310. It is done before it is put into the oven?—Yes.

9311. Is it expensive?—The first cost of the plant is heavy.

9312. It is done with a sort of ram?—No; the compressor we have has two chambers; first of all a hopper on the top into which the coal is put, then it falls down from this hopper into two chambers, and above those two chambers there are two hammers which are lifted with an electric motor.

9313. (*Professor Dixon.*) What do you reckon the cost of repairs at for the Simon-Carvès oven?—Well, if you ask me what the cost of repairs of our ovens last year was, it was 8·06d. per ton. That is rather a heavy cost, and that should not be taken as anything like the average cost, because in that we rebuilt altogether ten ovens completely.

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Mr. T. Y. Greener.

27 Jan. 1903.

9314. You were mentioning the difficulty of getting fire bricks?—Yes, but we have no difficulty in getting fire bricks to stand with the Simon-Carvès; we have rebuilt 10 ovens during the half-year, so that when you take the 8d. per ton as being the cost of repairs that must not be regarded as by any means the average cost.

9315. Out of a total of 108?—Yes, out of a total of 108; but those ovens have been working since 1881, so that they have had their life.

9316. That is a good life?—Yes.

9317. (*Mr. Briggs.*) Those ovens are much more durable than the modern patent ovens?—Well, these Simon-Carvès that we have in operation are small—23ft. long.

9318. They seem to have done exceptionally well?—Very well indeed.

9319. And you say your own fire bricks have done amply well for the lining of them?—Oh, yes; we have used nothing else, and we have supplied hundreds and thousands of bricks to the Simon-Carvès Company for ovens built on the Continent and elsewhere.

9320. A good deal of your coke is sold for foundry purposes?—Yes.

9321. Do you sell the patent oven coke for foundry purposes?—A very large proportion of it; some goes to blast furnaces.

9322. But nevertheless a great many of your foundry customers will take the patent oven coke and pay you practically the same price?—They pay more; it is always worth 1s. a ton more.

9323. I am speaking of the steam coke made in the Beehive oven?—They pay us the market price for foundry coke.

9324. Notwithstanding it is made in patent ovens?—Yes. There are many people who do not know that it is made in patent ovens.

9325. (*Mr. Young.*) I think you said that the loss, depending, of course, upon the management of the machine, in coal varies from 5 to 35 per cent.?—Yes.

9326. What is the percentage of dirt?—In our coals we wash out from about 5 to 9½ per cent.

9327. What is the loss of coal in your case?—The loss in the dirt in our coal I have known up to 25 per cent.

9328. In the coal?—I mean to say in the dirt, that is the free coal that is sent away in the dirt—in the washer. Of course, it ought not to be 25 per cent., but I have known it up to that.

9329. 25 per cent. of the dirt?—Yes.

9330. (*Mr. J. S. Dixon.*) Do you disintegrate the coal before you wash it?—Yes, we do both; we sometimes wash first, and in other cases we disintegrate first.

9331. Which is the preferable course?—I do not think there is the smallest difference. I took to washing disintegrated coal with very great doubt when we first undertook it, but it does not make any difference.

9332. Did you not lose a larger portion of the coal?—There may be a tendency of that sort; but, as a matter of fact, we found that the largest waste in the dirt was not at collieries in which we were washing disintegrated coal.

9333. I see you are putting up a large Coppée washer?—Yes.

9334. You think that is the best type of washer for your purpose, I imagine?—That is so.

9335. Can you explain the difference between the Simon-Carvès, the Coppée oven, and the Otto-Hilgenstock oven?—The great difference in principle is this, that in the Simon-Carvès the flues are horizontal; that is, the flues in the side walls; in the Otto Hilgenstock and ovens of that type they are vertical.

9336. You think that is an improvement?—There is no doubt about it.

9337. (*Mr. Briggs.*) Is the Otto-Hilgenstock fired from underneath?—Yes.

9338. There is a series of burners?—Yes, they have a series of burners.

9339. Bunsen burners?—Yes.

9340. They can be adjusted very easily from underneath the oven?—Yes; when you say "very easily," they can be adjusted, but it is not a very pleasant operation, because the temperature is pretty high.

9341. (*Dr. Le Neve Foster.*) You have no difficulty in disposing of your coke?—We have had no particular difficulty in disposing of our bye-product coke.

9342. Is there a prejudice against it in places?—Yes. There is no question about this, that iron masters, using coke made from their own bye-product ovens, are using stuff that they would not buy from us.

9343. You mean, then, that there is bye-product coke and bye-product coke?—I do not mean to imply more than I say, but if you were to go down to those works and see the coke which comes out of those ovens conveyed in bulk to the consumer's furnaces, and then see what he would return to us as bad coke, you would say there was a very great difference.

9344. Are you using any gas engine to utilise the gas?—No, I am not, but we are considering that matter now, and it is one upon which I have a perfectly open mind. I am not by any means clear that gas engines would not be more economical than any form of steam engine, but there is this great objection to introducing gas engines at a colliery, that you are introducing something entirely new with which neither workmen nor masters have had any connection before; and, therefore, you would have to train up, as it were, a new class of men—and that is a very strong objection, to my mind, to it.

9345. Does that not apply to everything new?—It does to some extent; but assuming we could get the same efficiency out of gas applied under a good boiler and an economical engine as we could from a gas engine I think I should prefer, and I think every colliery manager would prefer, to use the steam engine.

9346. Is not the first cost likely to be less?—That I am not quite clear about. We are thinking now of replacing 130 old ovens in one of the yards with a battery of bye-product ovens; and one of the reasons we have for taking that course is that we wish to have electric power to apply to coal cutting and other purposes at three pits which might be conveniently supplied from one centre. If we find it is cheaper to use gas engines and use the gas direct in those engines from the bye-product ovens, we shall do so.

9347. (*Chairman.*) Direct on to the motor?—Direct on to a gas engine.

9348. And drive the dynamos direct from the gas engine?—Yes; of course that means we should want a large storage.

9349. (*Dr. Le Neve Foster.*) What is the average percentage of ash in your coke?—About 7 per cent.

9350. (*Mr. Bell.*) These retort recovery ovens that you have spoken of as being put up by Bell Brothers and by Samuelsons are all put up at the works?—Yes.

9351. Not at the collieries?—No.

9352. Do you know anything about the kind of coal they use?—Yes, I know all about it.

9353. They do not use exclusively the richest coal?—Oh, dear me, no; they buy coal, as a rule, in the cheapest market: people like the Weardale Company, for instance, will use their own coal, but Samuelsons, who do not raise sufficient coal to supply their needs, buy largely in the market.

9354. Do they buy a certain proportion of lean coal to mix with the fat coal?—I do not know that they do that on any system.

9355. Probably they do find it now and then economical to do so?—They buy lean coal, certainly.

9356. (*Chairman.*) You said, as I understood, that the coking was done at the works; that means that they carry the coal to the ovens at the works instead of carrying the coke from the ovens to the works?—Yes.

9357. Is that because of concentrating their power at one point, or is it because there is some economy in using the waste gases from the retort coking ovens at the works?—It is on account of the latter reason. I know that one of the reasons frequently given is that the waste heat, or, rather, the power which may be obtained from the waste heat, is a saleable commodity in a town like Middlesbrough.

9358. (*Mr. Bell.*) Do you think there is also something in this, as I have heard it suggested, that by having their coke recovery plant at the works, they are in the market to take advantage of any sort of coal from

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any district, and that they enjoy greater advantages in that manner than they could possibly enjoy by having the work places at their own particular collieries?—Yes, there may be something in that, but I think the great reason, at all events, I know the reason that is inducing some people at Middlesbrough to put their coke ovens there is that they think they can sell the power from the ovens themselves. The reason you mention may of course have its influence, and I have no doubt it has.

9359. (*Mr. Briggs.*) Do they not charge their coke more or less hot into the blast furnaces?—Yes, as a matter of fact they do, but I do not think they claim any advantage for that.

9360. (*Mr. Bell.*) One of these works (I will not mention the name of one in particular) is even at this time importing small coal from Yorkshire?—I should not be surprised to hear it, but I do not know.

9361. (*Sir George Armytage.*) In reference to your observation about the economy of gas engines as against steam engines, do you take into account that a gas engine will require much less labour. The gas comes direct to you from a pipe from your oven, whereas with a steam engine you have to have people employed for the firing?

9362. (*Chairman.*) It is a question whether you use it direct in a gas engine or use it for firing the boiler?—Yes.

9363. (*Sir George Armytage.*) There is another thing I want to ask you: you mention about the ovens not being worked so economically in consequence of the time they had to be drawn and as to the labour of the men working in one shift. Can that not be avoided? I mean, would it not answer for you to pay your men to work at all times when you wanted to draw those ovens, and not to lose what you say you do lose by leaving the coke in the ovens?—Well, it is a matter for investigation as to whether it would or would not. I do not think it would pay us. *Mr. T. Y. Greener.* 27 Jan. 1903

9364. It has not been gone into?—It was gone into some years ago, and at that time the conclusion arrived at was that it would not pay.

9365. You mean the extra wage you would have to pay for working out of hours would not compensate you?—That is so. At the present time we work our bye-product ovens from 5 o'clock in the morning to 2 o'clock in the day. If we had to work them continuously we should have to put on three 8-hour shifts of men. We draw, as a rule, 36 ovens. If we could draw, by putting on three shifts of men, 56 ovens in the 24 hours, it might pay us. Assuming we are only increasing the ovens by four or five, I do not think it would pay us. However, that is not a matter I have gone into for some years past.

9366. You do not think there is a great element of economy in it?—I do not think so in our particular case.

FIFTEENTH DAY.

Wednesday, 28th January 1903.

PRESENT:

The CHAIRMAN.

Sir GEORGE ARMYTAGE.
Mr. BRACE.
Mr. BELL.
Mr. BRIGGS.
Professor DIXON.
Mr. J. S. DIXON.
Dr. LE NEVE FOSTER.
Professor HULL.
Mr. SOPWITH.
Mr. YOUNG.

The Secretary.
The Assistant Secretary.

Mr. GEORGE T. BEILBY, called; and Examined.

9367. (*Chairman.*) I understand that you have been good enough to say that you will read your proof?—If that is your wish I should like to do so.

9368. The Commissioners have not seen it yet, and I think that would be a very convenient course. Then we can ask any questions upon it afterwards. What are your qualifications?—I am a Fellow of the Institute of Chemistry, an Associate of the Institution of Civil Engineers, and past-President of the Society of Chemical Industry.

9369. I understand that in addition to your knowledge of chemistry you have had some practical experience of business. Will you kindly state what that is—what is your position at present?—I am an expert director of several large chemical and other works. I have myself passed through the stages of chemist and manager of works many years ago. I had about 20 years' experience of that kind, and since then I have been principally associated with practical chemistry as a director of industrial concerns.

The witness read the following statement:—

(1.) I have been for a long time associated with chemical and other industries in which large quantities of coal are consumed for the production of heat and power, and I have during recent years devoted a good deal of time and attention to the subject in its larger aspects as a national question. *Mr. G. T. Beilby.* 28 Jan. 1903.

In connection with that study an attempt was made some years ago to collect information as to the consumption of coal in various departments of industry.

No official statistics of this consumption existed, and it was necessary to collect information from many sources. As far as possible, rough checks were established by comparing figures from widely different sources, but necessarily a good deal of estimating had to be done.

As the object of the inquiry was to obtain a broad view of the whole subject in true scale and proportion, the absence of minute accuracy in the detailed items

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Mr. G. T. Beilby.

28 Jan. 1903.

is not a serious disadvantage; but I should consider that it would be for the benefit of industry at large if trustworthy statistics of consumption could be officially collected and published.

The statistics were originally compiled as for the year 1898, and were first published in July, 1899,* but for the purposes of the present inquiry they have as far as possible been brought up to date.

(2.) Taking the coal output of the United Kingdom at the round figure of 220 million tons and the exports as 60 million, there remains for home consumption 160 million tons; of this it is estimated that—

About 78 million tons is consumed for the production of power for industrial purposes.

46 million tons is consumed for the production of heat for industrial purposes.

36 million tons is consumed for the production of heat for domestic purposes.

Taking the first two items more in detail, it is estimated that for the production of power—

Railways consume - -	12 to 14 millions.
Coasting steamers - -	6 to 8 millions.
Factories - - - -	40 to 45 millions.
Mines - - - -	10 to 12 millions.

In the production of heat for industrial purposes:—

Blast furnaces consume -	16 to 18 millions.
Steel and iron works - -	10 to 12 millions.
Other metals - - -	1 to 2 millions.
Chemical, glass, potteries, and cement - - -	4 to 6 millions.
Gas works - - -	14 to 15 millions.

(3.) In considering these figures from the point of view of probable economies certain items may be eliminated as being too far outside of the scope of economies which are already known and proved.

In this class may be placed railways and coasting steamers, and to these may be added gas works, which are already very economical consumers of fuel.

The united figure is from 32 to 37 millions, and, deducting the larger figure from the total of 124 millions, we arrive at 87 millions as the item on which future economies will take most effect. Splitting up this figure again, we find that the consumption for power production at mines and factories is 52 millions, and for heat production 35 million tons.

(4.) In considering this item of consumption for power production, it is necessary to make some estimate of the work which is actually being done, and generally to consider in what way the coal is being consumed.

Broadly speaking, the 52 million tons is being consumed in steam boilers, and is converted into power by steam engines.

These installations are of all sorts of designs—good, bad, and indifferent—and they are working with every degree of efficiency or inefficiency.

For convenience they may be divided into three classes:—The large and economical, the moderate-sized and fairly economical, the small and wasteful.

Even in the first class there is not a uniformly high standard of efficiency. New installations with modern boilers and triple expansion engines of the best type, with ample condensing power are at the top of the class, while older installations designed and built under less favourable conditions may be at the bottom. The consumption of average coal per 1 H.P. hour will range from 2 to 4lbs. 3lbs. may be taken as a fair average.

In the second class may be included non-condensing engines, simple and compound, of the fairly large types, such as are used for pit winding, for rolling mills, and for the smaller class of factory engines where power is distributed by shafting. The consumption in this class will range from 4 to 6lbs. per 1 H.P. hour. 5lbs. may be taken as an average.

The third class will include the small engines and steam pumps planted all over factories and engineering shops in which motive power is generated near the spot at which it is required, steam being distributed by long ranges of pipes or generated in small imperfect boilers scattered over the works. The consumption of this class of engine may easily amount to 16lbs. for 1 H.P. hour, and it is not likely to be less than 8lbs. An average of 10lbs. will certainly be well within the mark.

For the three classes I have taken as the average figures 3lbs., 5lbs., and 10lbs. It is quite impossible to know what proportion these three classes bear to each other. Probably the second class is responsible for the largest part of the consumption. I will therefore take 5lbs. as the average for all classes, although this is not the arithmetical mean of all the figures.

As we are attempting to arrive at a safe figure on which to estimate future economies, it is better to take what we feel sure is a low average, so that in subsequent calculations there need be no feeling of exaggeration. I believe the majority of engineers would consider 5lbs. well within the truth.

By dividing the total figure of 52 million tons by this hourly consumption we arrive at an estimate of the total horse-power in use in Great Britian; it is equal to 5,320,000, i.h.p. per annum for 12 hours per day.

(5.) In considering the subject of the relative efficiency of various forms of heat engine it is desirable that the meaning to be attached to the term efficiency should be clearly laid down.

It is sometimes stated, even by experts, that the thermal efficiency of the steam engine is only from 10 to 20 per cent. of the theoretical. This statement is most misleading, and seems to result from comparing the total thermal value of the coal with the proportion of that value which is converted into useful work by the engine. The important fact is overlooked, that while mechanical work can be converted into heat of low grade without any loss of energy, the reverse operation is not possible. Heat can never be converted into mechanical work without loss of energy in the form of heat of lower grade. It is, therefore, quite misleading to regard mechanical work as only equivalent to a certain number of thermal units irrespective of the temperature at which the transformation from heat into mechanical work is to take place. Heat is only converted into work as it falls from one temperature to another and lower temperature. In the steam engine the steam as it enters the cylinder is at the top temperature, as it leaves the condenser it is at the lower temperature. If the steam engine were an absolutely perfect engine it could only convert into useful work a part of the total heat of the steam which it parted with in falling from the temperature of the boiler to that of the condenser. This ratio is expressed by a fraction in which the numerator is the number of degrees in the fall from the high to the low temperature, and the denominator is the absolute temperature at the high point, $\frac{100}{100+100} = \frac{1}{2}$ or = 50 per cent.

With steam at a pressure of 200lbs. per square inch, and with a condenser temperature of 100deg. F., the maximum possible amount of the heat of the steam which can be obtained as mechanical work by an ideally perfect engine, is only one-third or 33 per cent. of the total. When an actual steam engine gives a return of 21 per cent. of the total heat as mechanical work, its own efficiency is not measured by that small fraction, but is three times as high; it is two-thirds or 66 per cent. of the highest possible efficiency, so that on the best engines working with 200lbs. steam, no possible improvements could bring up its efficiency by more than one-third.

(6.) There are really two efficiencies to be considered as between the fuel and the mechanical work which it is used to generate. There is the extent of the opportunity which is afforded by the temperature which is imparted to the steam or other working substance, and there is a capacity of the engine to take advantage of this opportunity.

The increased efficiency of the modern steam engine depends on two developments which have gone on side by side, the increased range of temperature got by means of higher steam pressure, and the more perfect use of the fall of temperature by the expansion of the steam in two or three successive cylinders. The higher temperature supplied the opportunity for greater efficiency, and the triple expansion made use of that opportunity.

* President's Address, Society of Chemical Industry, Newcastle, 12th July, 1899.

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By still further raising the pressure of the steam, opportunity would be afforded for higher expansion in the cylinder, but it is doubtful if there is likely to be much further progress in boilers and engines of the present types.

(7.) Important results in increased efficiency have been obtained by super-heating the steam on its way to the cylinder. By applying heat at this stage the temperature of the steam is raised without raising its pressure. The possible range of engine efficiency is enlarged by this super-heating, the "greater opportunity" is supplied. In order to take advantage of this the engine must be so altered in design and construction as to enable it safely and economically to deal with the extremely hot super-heated steam.

As regards the practical developments of this system, it has been successfully applied to small and to moderately large engines. The steam consumption in these engines has been in some cases reduced to 12lbs. per hour, or even less; this is equal to about 1½lbs. of coal per i.h.p. hour. By super-heating, therefore, there is the possibility of reducing the coal consumption of comparatively small engines to that of the best and largest engines working without super-heating.

The drawbacks to the system are that it involves the introduction of a new piece of apparatus—the super-heater—between the boiler and the engine; this addition may be both costly and troublesome in working. Further, engines which are to use highly super-heated steam must be specially designed and very carefully constructed, in order that they may stand the extremes of temperature to which their various parts are subjected. Whatever success may attend the development of super-heating in steam engine practice will make for economy in the national coal bill for power generation; but it is not likely to be one of the really large influences in this direction.

(8.) The steam turbine, in its present form, is chiefly an improvement of the mechanical side of the steam engine. Its more extensive introduction for power generation in land stations will tend, like super-heating, to raise the general standard of efficiency in those classes of steam engines which are now of a comparatively low standard.

The designing of a gas turbine does not appear to me to be an impossible problem, and it is highly probable that it will be attacked before long. The construction of an efficient gas turbine would at once enable gas generation to take the place of steam boilers for marine propulsion.

So far as gas engines have been developed they are still too bulky and unmanageable for use for naval and marine purposes, but the perfectly successful adaptation of its near relative, the oil engine, to the driving of motor cars, shows that there are no insuperable difficulties in the way of producing compact and manageable gas engines.

(9.) The gas engine is now firmly established as the most economical of heat motors. Its general efficiency is due to the high temperature limit which is reached by burning the fuel directly in the cylinder. This efficiency ought therefore to be principally credited, not to the engine, but to the "opportunity" which is supplied by the form in which the fuel is presented. The significance of this fact in connection with the present inquiry is, that there still remains a very large field for the attainment of increased efficiency in the gas engine itself, both thermally and mechanically.

The position of the gas engine to-day may be compared with that of the steam engine in the early days of compounding. When the gas engine has arrived at the stage corresponding with that at which the steam engine has now arrived, the economical results will be correspondingly greater.

While the gas engine was restricted to ordinary illuminating gas as its fuel the conditions under which it could be used were rather limited, but even under these conditions there has been and will continue to be a considerable replacement of small steam engines by gas engines.

I might add on this point that I believe an estimate has been made that already there are in use small gas engines amounting to a horse power of about 500,000, in the form of gas engines, mainly using town gas.

(10.) A very great step forward was made when Mr. Emerson Dowson succeeded in applying fuel gas made from coke or anthracite to the ordinary gas engine. A new impetus was given to the use of gas for the generation of power, and engines of considerable size were built to run with this poorer kind of gas.

The heating value of illuminating gas is over 600 B.T.U. per cubic foot, that of Dowson gas is about 150 B.T.U.

After it had been amply proved that gas of this low value could be used in gas engines with efficiency and economy, it was only natural that the owners of blast furnaces should try whether the still poorer waste gases from their furnaces were available for this purpose. These trials were completely successful, and three or four years ago engines of large size were built for blast furnace gas in Germany and Belguim, and engines of moderate size were introduced at one iron works in Scotland. During the past few years the designing and making of large gas engines has been taken up with energy and enthusiasm in this country as well as in Germany and Belgium, and engineering firms in England are already making and delivering gas engines of 500 i.h.p. and upwards. In making this step from small engines to large many troublesome points in design and in construction have been met and overcome, and the gas engine of 500 to 1,000 h.p. is to-day a practical and trustworthy piece of machinery.

(11.) Simultaneously with, or following closely on the application of producer gas, made from coke or anthracite, to gas engines, gas made from ordinary bituminous slack in the producers of Mr. Wilson, Dr. Mond, Mr. Duff, and other inventors was specially purified and tried for the same purpose. This step also was completely successful.

Its significance from the wider standpoint is much greater than that of any of the preceding steps. While coke and anthracite gas necessarily depend on comparatively limited supplies of expensive fuel, producer gas made from ordinary bituminous slack draws its supplies of raw material from the largest and cheapest sources of fuel.

I think it may be accepted that this is the step which has made the generation of power by gas engines a national question in the broadest sense. There are now well-established results which show that power can be generated in almost any locality and on almost any scale with a consumption of 1lb. of average slack per i.h.p. hour. The influence of this new departure on the coal consumption of the country cannot fail to be enormous.

(12.) If the average steam engine and boiler installation of to-day with its minimum average consumption of 5lbs. of coal per h.p. hour, were entirely replaced by gas producers and gas engines, the 52 million tons of coal consumed for power purposes would be reduced to 11 millions. Obviously this replacement can only take place slowly, but it is sincerely to be hoped that as soon as the number of successful installations is sufficiently increased to place the practical and economic questions beyond all doubt, the British industrial leaders will grasp the situation as it ought to be grasped—as a great national opportunity. After the various methods of fuel preparation have been considered it will be possible to sum up the economic possibilities of the situation.

(13.) The question of coal consumption for the production of heat is necessarily more complex, as the methods and the purposes of the application are so varied.

The figure of 35 million tons which was arrived at by deducting the gas works' consumption from the total of 46 million used for industrial purposes, is mainly consumed in the iron and steel industries, blast furnaces using 16 to 18 millions, and steel and iron works 10 to 12. In English blast furnaces the coal is used in the form of coke. In Scotch furnaces raw coal is used.

The heat efficiency of the blast furnace is already on a high level—that is to say, there is not much prospect that the consumption of coal per ton of pig iron will be much reduced. I refer to the "Iron and Steel Institute Journal" of the autumn of 1893, in which Sir Isaac Lothian Bell has given his views very clearly and fully on this subject.

Indirect savings of considerable magnitude are still possible.

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Mr. G. T. Beilby.

28 Jan. 1903.

By the use of recovery ovens in the manufacture of the coke for blast furnaces a larger proportion of the heating value of the original coal would be made available in the form of tar and gas.

If the gases from blast furnaces were used directly in the gas engines instead of being burned under steam boilers, more than half of what is at present consumed would be set free for other purposes. The development of this economy in Germany and Belgium has already been referred to.

The distribution of energy in the form of a current of high potential electricity might be economically possible from blast furnaces as centres of power. The energy produced in this way might replace energy which is at present produced by the direct consumption of coal.

At a moderate estimate from 2,000,000 to 3,000,000 tons of coal might be saved in this way.

At present the consumption of power in the immediate neighbourhood of blast furnaces is not sufficient to absorb this spare power ; but if it were generally known to be available, users of power would be gradually attracted.

By bringing the steel and iron works within easy reach of the blast furnaces the superfluous gas might be used in these works either as heat or as power.

(14.) In the actual manufacture of steel the scope for further economy is not very large. Producer gas and Siemens' regenerator have already covered the available ground. In the manufacture of finished products from iron and steel there is still room for economy through the use of gas instead of raw coal.

(15.) In all the larger operations of the chemical works heat economy has received a certain amount of attention, and it is not usual now to find the extremely wasteful installations which were quite common 10 or 15 years ago. There are a number of purposes for which oil fuel and water gas are much better suited than raw coal ; their adoption for these purposes would lead to considerable economies of a minor kind. These remarks apply equally to glass works and potteries. In the firebrick industry gas firing has been successfully used by the Glenboig Company for many years. I understand that there has been no general adoption of the method in English firebrick works.

(16.) A large proportion of the heat used for industrial purposes is taken in the form of steam. The conditions under which steam may be most economically generated in boilers are fairly well understood by the larger users, and the majority of large and moderately large installations fitted up within recent years may be taken as efficient. Where fuel forms only an inconsiderable part of the manufacturing cost, there is a disinclination on the part of the manufacturer to spend money on the replacement of poor and inefficient plant.

The periodical inspection of boilers by the engineers of the Boiler Insurance Companies has had a very beneficial effect on the general style and efficiency of the installations under their care.

The loss of heat which occurs in steam boilers of good class ranges from 25 to 30 per cent. In low class boilers this loss may be 50 per cent., or higher.

By preliminary treatment of coal of inferior quality it may be possible to bring it up more nearly to the level of higher classes of steam coal.

" (17.) The conclusion to be drawn from a general survey of the present practice in the generation and use of heat from coal is, that while there is ample room for economy in many directions, there is no outstanding opportunity such as is found in the production of power. The future developments of production in industry up to a very considerable amount may, however, be readily met by economies in coal consumption without any serious increase of the fuel bill.

(18.) It may be well to point out that in works where heat in the form of steam is used, it is found economical to pass the steam through engines for power purposes, and to use it for heating only after it has given up the first of its energy. This may complicate the replacement of steam by gas engines in works of this class.

ECONOMIES IN PREPARING COAL FOR SALE OR USE.

(19.) I have considered coal washing and sorting chiefly as a preliminary to a further treatment by coking or briquetting. I have no knowledge at first hand of pit-head practice in this matter. Washing and sorting are valuable inasmuch as they dispose at the earliest stage of excessive mineral matter which is inevitably mixed with the small coal by the operation of mining. By crushing and sizing the coal before washing, any bands of inferior material which are interspersed through the body of the coal are also got rid of by the washing. In addition to the great reduction of mineral ash which results from washing, crushing and sizing provide a raw material of great homegeneity for the subsequent operations of coking or briquetting.

(20.) There are two fundamental propositions which apply to all questions of the more elaborate preparation of coal as fuel, either by coking, by briquetting, or by gasification ; these are (1) the intrinsic quality of the coal from each particular seam or set of seams worked in each and every district ; (2) the particular uses to which the fuel is ultimately to be applied. There are various of the older industries in which the principle of the allocation of special coals to special industries has always been recognised — the splint coals of Scotland to the making of iron in blast furnaces, the coking coals of England and Wales and their conversion into coke for use in blast furnaces, the steam coal of Wales and its use by the steamships of the Navy and of the Mercantile Marine.

More recently there has arisen the selection of non-caking coals, rich in nitrogen, for use in gas producers working with ammonia recovery. The wide field which has existed for selection has postponed till now the serious consideration of so treating the raw coal as it comes from the mine, that the economic fate of any particular industry need not depend on the life of one special seam of coal. There are signs that the consideration of this broad question can be longer deferred. Adjustments of a temporary kind are already in operation. In the illuminating gas industry the gradual failure of the supplies of cannel coal, and their consequent rise in price, has led to the extensive use of oil gas for the enrichment of poor gas made from ordinary coal. Other examples of a similar kind might be quoted. If the life of the Welsh steam coal supplies is to be prolonged, it will be necessary to find some substitute.

In order that the substitute may be of equal value, it must possess similar qualities. These qualities may be taken to be freedom from an objectionable quantity or quality of ash, freedom from excessive smoke in burning, a high calorific value, and a mechanical structure which will ensure that its behaviour in bunker and in furnace will enable its full value to be realised without waste or loss.

(21.) The natural differences which exist among coals from different districts and among the various seams in the district are so great, that the details of the manufacture must differ more or less in each district. While certain general methods may be evolved, the details of the problem must be worked out separately for each important class of coal. The adjustment of the quantity and the quality of the ash are well within the range of experience which already exists. The calorific value and the bunker qualities are also attainable. The problem is therefore practically reduced to finding the condition of incorporation which will give the necessary resistant quality in the furnace without the presence of constituents which will cause excessive smoke or smell.

The proximate constituents of many types of coal have already been studied in the laboratory, but it is probable that further study of the qualities of these at various temperatures may be necessary to enable us to arrive at the exact conditions under which a satisfactory incorporation may be obtained.

(22.) Some years ago I made the suggestion that partial distillation might be an important and valuable step in the preparation of smokeless briquettes. I have been interested to observe that this method has been adopted in various recent patents for the manufacture of briquettes.

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I consider that this problem would be best worked out by a small committee of experts familiar with the conditions under which destructive distillation and combustion processes are being carried out in the most modern works.

(23.) The production of coke in the United Kingdom is about 12,000,000 tons, most of which is still made in Beehive ovens. In 1899 it was estimated that recovery ovens made less than 1-10th of the total quantity of coke, or rather less than 1,000,000 tons. For 1902 it was estimated that this amount has increased to over 1,500,000 tons.

Apart from the gain of sulphate of ammonia which results from the use of recovery ovens, there is a very considerable saving of the fuel value of the coal distilled. This may take the form of a higher yield of coke, and, in addition, a considerable quantity of gas and of tar are obtained, both of which have a high fuel value. If Beehive ovens were entirely replaced by recovery ovens these two products would represent a coal equivalent of over 3,000,000 tons of coal per annum.

The modern re overy oven is an efficient apparatus for the production of hard coke for metallurgical purposes, but when hard coke is not required it is not the most economical means of separating the volatile constituents from coal.

(24.) The use of hard coke is not likely to be much extended. On the other hand, there is likely to be a considerable development in the use of water gas made by the Dellwik generator. For this purpose soft coke is perfectly suitable.

Water gas has a thermal value fully twice as great as that of generator gas, that is to say from 300 to 350 thermal units per cubic ft. It is therefore suitable for the production of high temperatures under conditions where regeneration cannot be applied.

The efficiency of the Dellwik generator is about 70 per cent. to 80 per cent. In this respect it compares favourably with other generators, and the only thing needed to make water gas a very cheap fuel is a proper supply of coke.

(25.) The great significance of the gas producer as the necessary complement to the gas engine has already been referred to. The successful use of this gas in large gas engines depends to an enormous extent on the perfect separation of water, tar, and dust before the gas is admitted to the engine.

The very large volume of gas to be dealt with—140 to 150,000 cubic ft. per ton of coal—makes the operation a very serious one. The plant for purification must necessarily be large and somewhat expensive.

In ordinary producer gas this expensive process has to be carried out without any adequate return in the shape of bye-products, so that the whole cost of purification must be debited to the fuel gas.

By the system of gas production which was first carried out by Young and Beilby in 1882, a very large proportion of the nitrogen of the coal was recovered as ammonia, and the value of this product more than repaid the cost of washing and purifying the great volume of gas. By this means a pure washed gas suitable for gas engines is obtained, and at a very much cheaper cost as fuel, owing to the value of the bye-product.

This system was developed by Dr. Ludwig Mond at the Winnington Works of Messrs. Brunner Mond, and the magnificent apparatus which he elaborated for this purpose is now known by his name all over the world. More recently various modifications of this apparatus have been carried out by Mr. Duff.

In the Mond and Duff gas producers, with their complete arrangements for recovery of bye-products and purification, means are now in our hands whereby the gas engine is provided with its supply of fuel at a cost less than that of the original fuel. This, combined with the high thermal efficiency of the engine, results in the production of power at a cost which is less than half that of the best steam installations.

Numerous large installations are in course of erection. Some are already at work. Within the next year or two a very extensive experience of the combined system will be available, and if this confirms the earlier results, the great saving of fuel, which has already been referred to, will begin to be rapidly realised.

Mr. G. T. Beilby.

28 Jan. 1903.

The cost of a combined gas producer and gas engine plant is estimated at about £13 per h.p. As the annual saving, as compared with an average steam installation, will not be less than £3 per h.p. year, the cost of plant will be wiped out within five years.

(26.) I must apologise for not having fulfilled a promise in an earlier part of this examination in chief to sum up the results, as my time was too short, and I must leave it to examination to supplement as you please anything that I have omitted. I should like, however, to make the following suggestions: — Clear, simple statistics might be published and brought expressly under the notice of the users of heat and power. These statistics should show the present state of consumption and the economic improvements which have been effected, and which are in process of development, as well as the cost involved in the replacement of old appliances by new. This statement would need to be issued by a committee of experts in order to avoid any appearance of partiality. The subject of fuel and combustion should be recommended to our Universities and Colleges as worthy of special teaching, study and research. It is one of the most important branches of industry, and provides a splendidly wide field for study and invention.

9370. (*Chairman.*) I do not think I have many questions to ask you. On the subject which you refer to of the desirability of trustworthy statistics of consumption being officially collected and published, is there any basis already laid down which could be elaborated?—There have been various papers read before the Statistical Society; these are the only collected results that I have been able to find. All my figures had to be got independently of that, but those figures given in the papers of the Statistical Society gave a foundation, as it were, on which to found the information.

9371. They are mostly gathered, I suppose, either privately or by or through some institute?—I think that is the only way in which it is possible to gather them.

9372. The Board of Trade does not render any help in that respect, does it?—Not so far as I know.

9373. In referring to the 10,000,000 or 12,000,000 tons of coal used for power under the sub-head "Mines," that includes coal mines, does it not?—Yes, I understand so. May I add that I have here a note of one or two of those papers which I spoke of, which perhaps you might like to put upon the notes. In 1890, in the Journal of the Statistical Society, Coal and Iron production was treated of by Chisholm; in 1889 Price-Williams dealt with the subject; in 1897 Dr. Leonard Courtney dealt with the coal question as treated by Jevons.

9374. In referring to the average consumption of coal per indicated horse power, you take as your average 3 lbs. for the best class?—Yes.

9375. In the second class you take 4lbs. to 6lbs., or an average of 5lbs. Does that mean that you put the difference between condensing and uncondensing as the difference between 5 and 3 or 3 and 5?—Yes, practically so; taking into consideration also the size of the units that are in use in the respective classes. I am not sure whether I made it sufficiently clear during the course of my statement, that, of course, I am considering in all these questions the coal consumption per horse power hour, and I am dealing with the average coal and not with selected types of steam coal, such as best Welsh coal. I am really thinking of the average quality of the coal which will make up these 52,000,000 of tons we are dealing with, which is, of course, very much inferior from a calorific point of view to the Welsh coal.

9376. Quite so; you begin with a total output of all the coals, and then work down to a point to see the quantity which is the margin for economy, or, at any rate, the margin which affords the greatest opportunity for economy?—Precisely.

9377. In speaking of the making of producer gas from the bituminous slack, I gathered that your point was to show that this cheaper kind of fuel could be used for that purpose. It does not follow that the bituminous slack so used would produce a greatly cheaper power than the better coal similarly used, does it?—No, the better the coal used, of course, the greater the economy would be.

9378. But it makes available for that purpose a large quantity of cheap material, which could not have been used in the old form?—That is the case.

9379. You make reference to the use of gas in the manufacture of steel Is gas used at all in the blast

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Mr. G. T. Beilby.

28 Jan. 1903.

furnaces?—No, it is a product of the blast furnace, but it is not used actually for the making of iron in connection with the blast furnaces.

9380. In speaking of the gases from these blast furnaces being used directly in gas engines instead of being burnt under steam boilers, you say that more than half of what is at present consumed can be set free for other purposes. Does that mean that the quantity used in a gas engine would produce the same power as double the quantity used under a steam boiler?—That is a very safe figure at which to take it, I think. I think the economy would probably be greater than that, because the boiler efficiency in using blast furnace gas is really a very low efficiency.

9381. And probably there would be the further economy that the whole of the gases produced are not utilised at present?—Precisely.

9382. That is to say, that if you converted them directly into power you would get more power per volume whatever may be the unit; in addition to which if you could convert them into power, you might be able to utilise the whole of them?—Yes, if you had an outlet for that power after you have produced it.

9383. Yes, that is what I understand. Then you state that at a moderate estimate, from 2,000,000 to 3,000,000 of tons of coal might be saved in this way. That, I understand, means that supposing you had an outlet, as you put it, for the power, there is power there which at present is going to waste?—Yes.

9384. If that could be utilised to take the place of coal, which is at present being used to produce that power elsewhere, that would be saved?—That was my meaning.

9385. You made a reference to the use of gas in the fire brick industry, and you said, "Gas firing has been successfully used by the Glenboig Company for many years. I understand that there has been no general adoption of the method in English fire brick works." Does that mean that the coal, instead of being used directly, is first converted into gas and then used in that form for firing?—Yes.

9386. Is that with a view to improving the product, or cheapening it, or avoiding smoke, or is it with a view to all those matters?—I think mainly it is with a view to improving the product, increasing the output of a given works, and also economy of fuel.

9387. The economy of fuel, I may take it, is greater, as you put it, if you convert it first into gas, and then use it in that form?—Yes, because regeneration becomes available, and the great mass of red-hot brick which has been already burnt is used as a means of heating the incoming air and gas for the burning of the next batch of bricks, so that, as it were, the heat in that first batch of bricks is made available, or a certain part of it is made available, in firing the next lot of bricks. Of course that method of heating can only be carried out with gaseous fuel.

9388. In that way of producing gas is the gas in a form in which it can be controlled or stored?—No. It is used direct from the producers without preliminary washing or cooling.

9389. When you speak of the preliminary treatment of coal of inferior quality, and that it may be possible to bring it up more nearly to the level of higher classes of steam coal, is washing one of the preliminary treatments which you have in your mind?—Yes.

9390. With regard to the interesting question of briquettes to which you have referred, I gather you have no great personal experience of them?—No.

9391. But you incline to the opinion that a careful examination of the question might result in the production of a briquette, which would be at the same time clean and heat-giving?—Yes; I hold that view very strongly.

9392. The object being, as I understand, to avoid the waste by smoke?—Yes, but also to make the briquette as good a steam-raising fuel as the Welsh steam coal; that is, say, to enable the coals of inferior quality to take the place to a certain extent of the very high-class coals of Wales.

9393. Or, to begin at the beginning, do you think it is possible by converting the small anthracite coal into briquettes to raise as much steam with the briquette as with the coal?—That has not yet been attained, but I think there is room for considerable improvement in that directon. At the present moment coal dust briquettes made with Welsh coal dust, I understand, are very considerably behind the original coal in their thermal qualities, but I think there is room for possible improvement still on the methods by which those briquettes are made.

9394. Then you do not think that the mere size of the coal has anything to do with the power of raising steam?—Below a certain size it certainly has to do with it—I mean the reduction below a certain size is obviously a disadvantage.

9395. Would that be overcome by restoring it to the larger size in the form of a briquette?—That would be so, certainly; and I think one of the points that has to be settled is what mechanical form the briquette had better be put in. We have accepted a certain block, more or less, as a standard, I think perhaps without very good reason. I think the reasons why that block is to be accepted as a standard ought to be made more conclusive.

9396. I observed that in an interesting paper which you read when you were President of the Society of Chemical Industry,* and which I had the opportunity of reading, you questioned whether the size or form of it was the best?—I think for domestic purposes it is the very worst possible form at the moment.

9397. Is it too thick?—It is very much too thick and too massive. It is too difficult to light and too difficult to keep alight.

9398. There are two points really; that you think it may be possible after careful inquiry to use the small coal from the higher qualities, the best qualities, of coal—to make it into briquettes, and so nearly compete with the larger coal of the same class; and, secondly, that by utilising other coal not so good in the form of briquette it raises the value, at any rate, of the small coal all round?—I hold that opinion strongly.

9399. And that it renders it available for purposes for which it is not at present available?—Yes, and also contributes very largely to a reduction of the smoke trouble by giving a more perfect fuel.

9400. Do you hold that smoke is all waste?—No. I do not think we can necessarily measure the waste by the smoke. I think that very often smokeless combustion is more wasteful than smoky combustion. I should like to direct your attention, if I might, at this stage, *àpropos* of briquette making, as you have raised the question, to a report by the United States Consul, which is possibly already in the hands of the Commission. It is dated August 16th, 1902, and is a report on briquette making in Germany. It is a very important document, I think, because statistics of a very valuable nature are given. *See* Appendix V

9401. There is a reason in Germany, is there not, for more attention in the past having been given to the question of briquette making, owing to the fact that a larger proportion of their total output of coal is, in the first place, small, and, in the second place, of inferior quality?—Yes. I think that has contributed very much to the interest that has been taken in Germany in the increase of briquette making.

9402. It does not detract from the importance of your suggestion, namely, that our own small coal might possibly be made of much greater value by converting it into briquettes?—It does not.

9403. There is a word in your statement which I do not quite follow. In speaking of the efficiency of the Dellwik generator, which you put at 70 per cent. to 80 per cent., you say: "In this respect it compares favourably with other generators, and the only thing needed to make water gas a very cheap fuel is a proper supply of coke." What does the word "proper" mean in that sense?—The proper kind of coke, and in sufficiently large quantity to make sure that the manufacturer who adopts water gas does not find himself suddenly in the position of having to pay a very high price for his coke.

9404. Is there any particular kind of coke that is necessary for the purpose?—No. In practically working the Dellwik plant—I think I have the largest plant in existence for that system at work in Glasgow—our experience is that we can work a very considerable variety of cokes in it.

9405. Therefore "proper" in that sense would mean, rather, an ample supply?—It means really an ample supply at a sufficiently moderate price.

* President's Address, Society of Chemical Industry, Newcastle, 12th July, 1899.

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9406. But apparently you have been successful with the water gas?—Yes, very sucessful, for certain purposes.

9407. It is merely for heating, is it?—Entirely.

9408. You have had no accidents?—We have had one or two, but none fatal, I am glad to say. Such accidents tend to diminish, as the men become familiar with what they are dealing with; and, of course, it is always absolutely necessary to have an ample supply of compressed oxygen with an inhaling mask within easy reach, so that when a man is "gassed" a restorative can be applied.

9409. You made reference to the Mond and Duff gas producers, and you said that by this producer gas, as I understand, power can be produced at a cost which is less than half of that which the best steam installations will give?—Yes.

9410. It is necessary, is it not, in order to reach that economy, to be working on a large scale; you cannot do that on a small scale, can you?—No; the fullest economy depends upon the recovery of the sulphate of ammonia as a bye product.

9411. That fixes a minimum, does it?—It fixes a minimum of possibly 60 tons per day, or something like that.

9412. (*Sir George Armytage.*) In reference to the last question with regard to the Mond and Duff gas producers, which you say could work at about one half the cost of a steam-engine, about what size of plant would you require to arrive at that economy: I mean, would it have to be put down in a town and all the mills in that town take it, or is it an apparatus which could be economically used at any very large works?—I think, when we consider this matter, we ought to look at it from two points of view: for the highest economy, in which necessarily the recovery of the ammonia as a bye product is involved, a certain minimum size, we may say of 50 or 60 tons of coal per day, is necessary; but below that minimum there is still very considerable economy in the use of gas as against steam in the smaller installations, and where no recovery of bye products is attempted. There I should say the economy probably will be quite equal to a saving of half the present average cost of steam power—even in those cases.

9413. (*Chairman.*) Probably the use of the small steam engine is a still more wasteful process than that of the large steam engine?—Yes, very much so.

9414. (*Sir George Armytage.*) But the man who has the small steam engine would naturally not have the means to put down a plant for a Mond gas producer. What I wish to arrive at is, what is the minimum which would make it worth the while of any corporation or body of manufacturers to put down an apparatus amongst them? I gather from you that it would be something like a consumption of 50 or 60 tons of coal per day?—That only refers to the highest economy, but a very great economy is to be got even with a consumption of 5 tons per day. I inspected yesterday an installation in which only 5 tons per day were being consumed, and two large gas engines were being run from it with great economy.

9415. (*Professor Dixon.*) Was that Mond gas?—Yes.

(*Sir George Armytage.*) Do you know whether at the present time the Mond system is in operation by any corporation, or any company, or any combination of manufacturers, or anything of that kind?

9416. (*Chairman.*) There is a Mond Company, of which Sir Henry Fowler is the chairman, is there not?—That is the Power Gas Corporation.

9417. Does that supply power gas over any large area?—No, that corporation exists purely for the purpose of erecting plant.

9418. (*Sir George Armytage.*) That is the company for manufacturing the plant?—Yes. There is the South Staffordshire Mond Gas Company or Corporation, which has obtained Parliamentary powers to supply gas and power to consumers.

9419. Are they doing it practically now?—The works are at present being erected, but nothing has yet been done in the matter of distribution.

9420. Then we have really no information at present as to the practical result of it?—From the corporation point of view, no. Amongst private works there is a good deal of information.

9421. If it will succeed with private works, it must necessarily succeed still better on a larger scale?—Certainly.

9422. Has not the question of the distance to which it is to be conveyed to be considered?—Where gas has to be distributed, certainly the distance is of immense importance.

9423. Therefore the important thing from the mechanical point of view would be to have the apparatus close to the coal pit, I suppose?—No, not necessarily, I think. I think it is better that the apparatus should be at a point from which it can draw supplies from a variety of coal districts. I think the small extra cost of carriage is quite compensated for by the opportunity of getting coal from different districts and of selecting, more or less.

9424. (*Chairman.*) That seems to be rather a good point; it was made yesterday, I observe, by several of the witnesses, on the question of coke, that the coke is not necessarily made at a colliery, but made at a point, as you put it, where supplies of coal can be drawn from several districts?—Yes; I think all experience tends to show that that is the right way to deal with the subject—not to tie oneself up to a particular pit or set of pits; it is always dangerous to do so.

9425. (*Sir George Armytage.*) Now, upon this big question of the economy of fuel, has your attention been called at all to the desirability of distributing electric energy from a centre?—Yes, I have looked into that question a good deal.

9426. And have you formed any general idea as to what economy could be arrived at from that course?—I think the chief economy in that case will certainly be to the small consumer; that is to say, you will be able to put him in the position of the economically large working units, and give him a part of the benefit, at any rate. I look forward to the replacement in this way of a large number of the very inefficient steam installations which at present exist. I think we may almost look forward to the time when the small steam engine will be a thing of the past.

9427. And do you think that will benefit the small steam engine man more than it will the people who have larger appliances?—The people who have the larger consumption of power will naturally prefer to get the whole benefit for themselves by manufacturing their own electric energy.

9428. Yes, quite so; but do you think the smaller men will get a bigger benefit than they would by sharing in a still larger concern? I mean the theory of these large companies, which are to take hold of the whole county, is, that by having this large installation in one or two or three places quite close to the coal pits, they will be able to supply electric energy cheaper than people can make it for themselves. Is not that so?—Yes, that is the idea.

9429. I wanted to ask you whether you had really worked that out at all?—I should think that economy would not be felt by a really large consumer—by "large consumer," I mean a consumer of a good many thousands of horse power; I think he will always be able to get more benefit by establishing his own installation.

9430. Do you happen to know what is the cheapest rate at which electric energy is produced now in the kingdom?—I do not know the statistics of the companies that are expressly supplying it; I do not know the lowest rate at which they are supplying to consumers.

9431. No, but I mean, do you know the cheapest rate at which it is made?—I think by means of steam engines it is very difficult to get the cost below £7 or £8 per electrical horse-power year. I happen to be associated with one large electrolytic work in which 6,000 or 7,000 h.p. is generated at the present moment, and during the last few years it has not been possible to get the cost much below £8 per electrical horse power year, and that is with a load factor of 100 per cent.

9432. (*Mr. J. S. Dixon.*) What is that per Board of Trade unit?—An electrical H.P. is about three-quarters of a Board of Trade unit.

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Mr. G. T. Beilby.

28 Jan. 1903.

9433. (*Sir George Armytage.*) It is about three-quarters, is it?—Yes.

9434. (*Mr. Briggs.*) You may say about £10 per Board of Trade unit?—Yes; I should consider that a very cheap cost price with average coal prices for steam-produced electricity under favourable conditions.

9435. (*Chairman.*) How much is that?—About £10 or £11 per Board of Trade unit per annum. I know that statements of very much lower amounts are put forward with regard to the cost, but I rather doubt, if these were worked out in a business-like way, whether they would show that.

9436. It is produced at ½d. per Board of Trade unit at present, is it not?—Yes. It can be produced at about ¼d. per Board of Trade unit now by steam; but then we hope, by the introduction of the recovery producer and the large gas engine, to reduce it to about $\frac{1}{10}$d; that is to say, to bring it down to about one-third of the present cost; in which case we shall be in a position in this country to have our electrical energy at a price which is substantially less than that available at Niagara or Rheinfelden. At Niagara the cost of electrical energy is about £4 per electrical h.p. year, and at Rheinfelden it is about £6.

9437. (*Sir George Armytage.*) When you say "per year," I suppose you reckon working 12 hours per day?—No, that is working continuously—24 hours per day.

9438. That makes a great deal of difference?—I am speaking of it now purely in connection with electrolytic work, in which the current is taken continuously—all day and every day.

9439. With regard to what the Chairman has asked you about smoke, have you formed any opinion as to the amount that is wasted by smoke which is not properly consumed by manufactories, coal-pits, and other places?—I do not think the actual smoke really accounts for a very large percentage. I think it seems to show a great deal more waste than there really is; it may indicate a faulty state of things generally in the combustion of the fuel, but the smoke itself does not necessarily mean much waste; in fact, as I have said already in answer to a question of the Chairman, it is not the highest economy to work a boiler from the smokeless point of view; it is more economical to work it with slight smoke than on the absolutely smokeless plan.

9440. (*Chairman.*) But that is rather a different question. The real point is, never mind about working with a boiler, but if you like, by means of producing machinery; does the smoke as it passes away contain heat, and could it, by any process, be turned into heat or power?—Not economically.

9441. (*Sir George Armytage.*) But, roughly speaking, it is much more economical to fire mechanically than by hand, is it not—that is to say, if it is carefully done?—Yes, very much.

9442. Have you considered whether that can be done still more efficiently — whether there are not several works which are not economically worked in that way, which must necessarily mean great waste of power if they are not? Do you think that where there is the most efficient mechanical stoking it is the best that can be done, or is there anything that can be improved upon in regard to it?—I do not think in the burning of solid fuel there is much improvement to be made upon the best mechanical stoking if in addition there is perfect control of the furnace gases by analysis, to be quite sure that the air supply has been properly regulated.

9443. (*Chairman.*) But I gather that your opinion is that a ton of coal may be made to produce a larger amount of heat or energy if converted into gas and used in that form rather than by being burnt as coal, as it would be burnt in a furnace?—The answer to that is not perfectly simple. By converting the coal into gas there is a necessary loss of heat in the conversion. In any form of producer there is almost necessarily a loss of from 20 per cent. to 30 per cent. of the total value of the heat, but after incurring that loss a more valuable fuel for many purposes is obtained in the form of gas, and the economies in the use of that prepared fuel, if one may call it so, more than compensate for the early loss of 20 per cent. to 30 per cent. in the production of that better fuel.

9444. If I understand your views aright, you would agree to this general proposition, that by means, first, of the producer gas, and, secondly, by the use of the producer gas in a gas engine, you get, as you put it yourself, power at half the cost?—Yes.

9445. That economy, I take it, would be distributed in some unequal or equal proportions, first to the recovery of something which otherwise would not have been recovered, and otherwise would have been lost, and, secondly, to the utilisation of the power in the most effective way?—Yes, that is so.

9446. And, of course, avoiding smoke?—Also avoiding smoke.

9447. (*Professor Dixon.*) There is one passage in your proof which I think might lead to some misapprehension. It is with regard to superheating steam on its way to the engine; you say, "By applying heat at this stage the temperature of the steam is raised without raising its pressure." Then you go on to speak with regard to the use of extremely hot superheated steam. It would almost look from your phrase that you thought that mere high temperature would be effective without high pressure. Of course, that cannot be so?—Well, you are, of course, increasing the range over which the efficiency is to be made; that is to say, you are increasing the difference between the temperature of your boiler and your condenser.

9448. But take the extreme case of a very hot gas, and where you get, say, a flame put into a cylinder under atmospheric pressure, it would do no work at all?—No, but the same gas, when it is confined in a gas engine cylinder does do the work, of course.

9449. It is under high pressure?—It necessarily produces the pressure, of course.

9450. But your phrase here looks as if you thought the pressure did not matter?—Yes, of course, it does.

9451. It is a little misleading?—I am obliged to you for your suggestion; there is a possible misunderstanding.

(*Chairman.*) It maintains the pressure.

9452. (*Professor Dixon.*) It maintains the pressure?—Certainly.

9453. Then the next point is with regard to the interesting subject of gas turbines and their possibility for use in marine propulsion. Have you thought about that at all, and have you given your ideas on the subject?—I am not in a position to do that. I have discussed it a little with engineers. It seems to me distinctly that there are possibilities.

9454. Was your idea to have some explosive form of gas and air to drive the turbine?—Yes, that was the idea.

9455. Would it be necessary to make the gas on board?—I think it would be just as easy to make producer gas on board ship as to produce steam by steam boilers. Producer gas is quite a possibility.

9456. Oil, of course, would do. Then with regard to the efficiency that has now been reached in the case of the blast furnace; I suppose in England that efficiency has been increased considerably in the last 10 years?—Very considerably; by increasing the height of the furnace and otherwise.

9457. Are you familiar with the American practice as regards blast furnaces?—Only in a general way.

9458. You know they have increased their efficiency enormously?—They have.

9459. Have you thought about the use of commercial oxygen in a blast furnace?—No. I have thought of it in another connection for furnace work.

9460. You could not give us any views as to how much that could be increased if you could get 50 per cent. of oxygen cheaply?—No. Obviously it would increase the efficiency enormously.

9461. Yes, because the temperature would be raised so much?—Yes.

9462. Then a few pages further on in your statement with regard to the inspection by boiler insurance companies, you say "The loss of heat which occurs in steam boilers of good class ranges from 25 to 30 per cent." What does that particular loss refer to there?—

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I mean the general losses through heat being dismissed in the production of combustion and radiation losses, and losses through inefficiency of combustion.

9463. And not due to incrustation or things of that sort?—No, I was in every case thinking of a boiler kept in good condition with good feed water.

9464. You mean the loss entirely due to combustion?—Combustion and normal losses.

9465. Then you pass on to the Mond and Duff producers. Have you had practical experience of those?—Yes.

9466. You have Mond gas at work?—Not in any of the works I am at present dealing with. We are at present putting up a large installation, which I think will be started before the end of the month; but I have not actually had one of the modern installations at work under my own eyes. In 1883 and 1884, when we were working at the beginning of this thing, I was actually producing gas of the same analysis and using it quite regularly.

9467. Do you know where the Mond gas is actually at work now besides at the works of the Brunner Mond Company at Winnington?—I have here a list of installations which I think might be of interest.

9468. If you will put those in I think they will be useful?—Of course, the installation at Northwich has been working for quite a number of years. There the equivalent horse-power is 25,000. The following is a list of installations:—Messrs. Brunner, Mond and Co., Ltd., Northwich; Messrs. William Beardmore and Co., Ltd., Glasgow; Messrs. William Beardmore and Co., Ltd., Glasgow (second installation); Messrs. Sir W. G. Armstrong, Whitworth and Co., Ltd., Manchester; the South Staffordshire Mond Gas Co. (first station only); Compania General de Productos Quimicos del Abono, Gijon, Spain; the Salt Union, Ltd., Liverpool; the Solvay Process Co., Detroit, U.S.A.; the Farnley Iron Co., Ltd., Leeds; the Gastner-Kellner Alkali Co., Ltd., Runcorn, Cheshire; the United Alkali Co., Limited, Fleetwood, Lancs.; Messrs. Albright and Wilson, Ltd., Oldbury; the Trafford Power and Light Co., Ltd., near Manchester; the United Turkey Red Co., Ltd., Alexandria, N.B.; the United Turkey Red Co. Ltd., Alexandria, N.B. (extension of plant); Messrs. Monks, Hall and Co., Ltd., Warrington; Messrs. D. and W. Henderson and Co., Ltd., Glasgow; Messrs. Cochrane and Co., Dudley; the Great Southern Railway Co., Buenos Ayres; Messrs. Ashmore, Benson, Pease and Co., Limited, Stockton-on-Tees (the Power Gas Corporation's Works); the Buenos Ayres Western Railway Co., Buenos Ayres; the Premier Gas Engine Co., Ltd., Nottingham; Messrs. Handyside and Co., Ltd., Derby; the Railway and General Engineering Co., Ltd., Nottingham; Messrs. Tweedales and Smalley, Castleton, Manchester; Messrs. J. and H. Robinson, Ltd., Deptford Flour Mills, Deptford; Messrs. Cadbury Bros., Ltd., Birmingham; Messrs. Crossley Bros., Ltd., Manchester; the University, Birmingham. Messrs. William Beardmore, in Glasgow, I think, are using it both for heating and for power purposes. They have an installation already at work of 20,000 h.p. I mean the gas produced is equivalent to that, but I do not know that they are actually converting that into power. That is equivalent to 200 tons of coal per day. Perhaps that is the best way to put it.

9469. How many actual towers would that mean?—That simply means enlarging the number of producers. I have here a diagram that may interest you.

9470. There is a limit to the size of the producer, I understand?—Yes, the 20-ton producer. (*The witness handed in document.*) That is a purely diagramatic view of the towers and arrangements in question.

9471. You say you have no personal experience as to the working of it under your own charge?—No, I hope to have in a short time.

9472. Do you know as a matter of fact what sort of coal can be used in a Mond producer?—Of course, one naturally takes a coal with the highest possible nitrogen contents, and then after that the caking quality is the most important matter—that is to say, a fully caking coal cannot be worked in these producers, because it would lead to hanging; so that a selection is made of those coals which will work without excessive caking, and which contain as much nitrogen as possible. These are the only two conditions necessary.

9473. Do you know whether those conditions are satisfied by a large number of coals?—Yes, by quite a large number, I believe. At the present moment I think there is no serious restriction as to the districts that one can draw from.

9474. Do you speak now from personal knowledge?—I am speaking from having had to do with the making of forward contracts for these large plants Of course, one naturally tries in the first instance to get coals that are thoroughly approved and that have been worked already, because, to begin with, it is better to have something that is assured and that one knows about.

9475. You mean like the Nottingham coal?—Yes, the Nottingham coal comes in there; but I have no reason to believe that there will be any serious restriction. At the same time the development of the plant is going on in the direction of making it available even with caking coals or slightly caking coals.

9476. Do you know whether it has been successful with the Lancashire coal?—I cannot say as to that from my personal knowledge.

9477. Then have you any knowledge of the Duff plant?—The same general knowledge as I have of the other.

9478. Do you know the Armstrong-Whitworth Company's works?—No.

9479. (*Mr. Bell.*) Are you speaking of slack entirely in referring to coal?—I am speaking of slack entirely. Of, course, the essential difference between the Duff and the Mond producer is merely one of the producer itself; the other plant practically amounts to the same thing.

9480. (*Chairman.*) Have they got an installation at Elswick?—No, they have not put one down there yet. The Armstrong-Whitworth Company are doubling the installation at Manchester.

9481. (*Professor Dixon.*) The composition of the gas produced by the Mond and the Duff, I suppose, is very much the same?—Yes, so far as I know. On the whole the Mond gas seems to be rather more steady and of better composition; that is to say, I think the regulation of everything is a little more perfect, so that the quality does not alter much.

9482. Have you any analyses which you have made?—I have none of my own analyses, but I can easily give you analyses which have been published.

9483. I have some of those.—I have analyses of my own of the same gas made in the earlier days—in the eighties.

9484. May we have those?—Yes.

9485. What did you succeed in getting—40 per cent. of combustible, or 38 per cent., or what?—CO_2: 16·6 per cent.

9486. Are these the figures of the original?—This is the actual analysis made in 1883 or 1884; then 8·1 per cent. of CO: 2·3 per cent. of CH—that really means hydro-carbons of any kind: hydrogen 28·6, and nitrogen 44·4 per cent.

9487. The chief difference between them and the present gas is, I think, that there has been less carbonic acid in the Duff and Mond gas and more carbonic oxide?—Yes.

9488. Then I think you told us that you had had experience with the Dellwik water gas?—Yes; in a Glasgow works with which I am associated we have a very large installation—I think the largest they have made yet.

9489. What has that been used for chiefly?—It has been used for metallurgical and furnacing purposes by the Cassel Gold Extraction Company.

9490. It is not used for welding, or anything of that sort?—No, not by us.

9491. Have you had any difficulty with the valves connected with the reversing gear?—Yes, we had to make some alterations upon those.

9492. Did you have any explosions?—We had one explosion, but we were not able to trace to what cause it was to be attributed. I do not think it was associated especially with the reversing valve; I think one of the other valves leaked a little. The reversing valves were found to be very troublesome at first, but we have had modifications made in them, and now we have absolutely no trouble.

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Mr. G. T. Beilby.

28 Jan. 1903.

9493. Is that public property?—Yes, I think the modifications have been adopted by Mr. Dellwik himself; he has seen what was done.

9494. That was really one of the difficulties in working the Dellwik water gas?—Yes; I think we have no real difficulty now.

9495. You have no knowledge, I suppose, of the transmission of producer gas, or Mond gas, in long pipes?—No, I have not.

9496. It has been proposed, I think, in Staffordshire, to send it in 9in. pipes?—Yes.

9497. Are you using gas engines with this?—No; it is purely for heating purposes.

9498. Are you using steam at all?—No, not at all—except for furnace purposes.

9499. The price of sulphate of ammonia is well kept up, is it not?—Yes, it is higher just now than it has been for six or seven years, I think; it is about £12 per ton.

9500. (*Dr. Le Neve Foster.*) Might I ask a question or two about the collection of statistics. You are strongly in favour of statistics with regard to the consumption of coal being official?—Yes.

9501. By what Department would you have that done? The Home Office are now collecting statistics for the total output. What you suggest is that they should improve their statistics and give figures relating to quantities used in different industries?—Yes, I think the most natural form for the new statistics to take would be merely to supplement those which are at present published in connection with production. If the consumption could be added, as it were, to production, I think it would be desirable.

9502. In what way do you think that could be done?—I have not really considered that in any practical way.

9503. Would you have the coal-owner endeavour to give the Government some figures and to give the best information he could, saying to what purposes the coal was put or sent?—He would need considerable guidance, I should think, to enable him to give that kind of information in the form in which it is wanted.

9504. Or would you get the manufacturers to give it by a return?—It would be much more satisfactory if the manufacturers could be got to give a return; it would be then much more authentic, of course.

9505. This is to say, of the quantity employed in their industries?—Yes; and I do not see that there ought to be any very serious difficulty in doing that in confidence. Their names being necessarily repressed, there ought to be no difficulty in providing that information.

9506. Then it would come to this, that you would ask the Government to send out a form to a manufacturer, and ask him to fill it up, and to say how much coal he had used in his industry during the year?—Yes.

9507. And you would ask the Government to publish general figures concerning the industries, or concerning the different counties, probably. Is that your idea?—Yes, that is my idea.

9508. Would you have a statement of the quantity of coke produced and briquettes produced as well?—Yes.

9509. In your statement you include gas-works under the head of production of heat for industrial purposes?—Yes.

9510. For the convenience of people studying economy, would it not be well to say "production of light"—production of a material for lighting purposes?—I think that would be a very much more scientific way of defining it.

9511. But would it not also be convenient from the point of view of economies in burning gas for lighting purposes?—I am not quite sure that I apprehend your point.

9512. We want to see how economies are to be arrived at?—Yes.

9513. One economy would be a production of a larger amount of light from a similar quantity of gas?—Yes.

9514. That being the case, would it not be well to separate the gas used for lighting from gas used for heating?

(*Sir George Armytage.*) That is to say, putting it under three heads—power, heat, and light?—Yes, power, heat, and light. I think that would be a much better classification.

9515. Perhaps you might do that in the summary which you have been good enough to promise to make?—I will make a note of that. Of course, with reference to the consumption of 12,000,000 to 15,000,000 tons for gas-works, I have not gone into that at all, because I take it that, from the heat production point of view, the gas-works are already on a very high level; their use of fuel within their own borders is exceedingly economical.

9516. (*Dr. Le Neve Foster.*) Yes, but then, from the point of view of the saving of coal, you have to look at the manner in which the consumer uses the gas for getting light?—Yes.

9517. Admitting that there is a saving in producing energy by gas in the place of steam, how do you find the first cost of a gas plant compares with the first cost of a steam plant?—I can only speak very broadly, but I think on a high-class installation there would not be much initial difference.

9518. On which side would it turn?—Engineers' estimates vary so greatly that I find it impossible to make any general comparison. In one case I know of, gas engines and producers were actually cheaper than steam engines and boilers, but in each case one would need to specify the exact kinds of engines referred to.

9519. (*Sir George Armytage.*) Would the gas plant include producers?—Yes.

9520. (*Dr. Le Neve Foster.*) Yes; I mean the total plant. Then for how small a factory, for instance, would it be economical to put up a gas plant?—You mean the actual generating and washing plant. Mr. Dowson, with his producer, has put in very small plants.

9521. 100 horse-power?—For 50 horse-power, I think, it becomes worth while putting in a small plant.

9522. Without the recovery of bye products?—Yes, and having to use in that case anthracite or coke as the fuel.

9523. You are driven to that?—Yes, because you cannot use the bituminous coal in these very small producers.

9524. And you might be driven to paying a high price for your anthracite?—That is so.

9525. Then with regard to the question of combustion of fuel, have you studied at all the using of small coal in the form of dust?—Not at first hand at all.

9526. With regard to the shape of the blocks or briquettes, is not the shape of the block mainly settled by its convenience for stowing in bunkers?—I should think it would be to a very large extent.

9527. Therefore you would advocate one form for domestic use, and another form for use on board ship, I take it?—Yes. I can imagine that for domestic use a perforated briquette would be very much more useful as fuel.

9528. Or a round briquette?—Yes; but I think you want freer access of air than would be given by any solid block.

9529. Say a perforated ovoid?—Yes; or there is no objection to perforating a square or oblong block.

9530. Have you had any experience with regard to the apparatus sometimes employed for analysing chimney gas as a means of controlling combustion?—In various works I have had such control analyses going on quite regularly, but of late years I am afraid I have lost touch with the laboratory methods.

9531. Do you find them of real practical use in controlling your stoking?—Yes, most decidedly.

9532. Have you had anything to do with an apparatus which makes analyses automatically?—I only know of the existence of that apparatus; I have not used it at all, nor had it in use.

9533. I understood you to say that in any works where you are using producer gas you ought to have bottles of compressed oxygen and a mask ready. Do you refer to quite small works?—I refer to a works of any size, wherever a gas rich in carbonic acid or oxide is found; and I think the presence of oxygen ought to be insisted on in the works, and in such a thoroughly available form that everyone should know where to turn for it at a moment's notice.

9534. You would have your men drilled in the manner of using it?—Yes, certainly.

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9535. So that every man should know on the spur of the moment how to apply it?—Yes, that is most important, I think.

9536. I have a further question to ask you with regard to domestic uses. You have said nothing here on that point; but the quantity of coal employed for domestic purposes is 36,000,000 tons?—Yes, it is enormous.

9537. Have you any suggestion to offer?—I think the only hope there—it is probably a matter which extends in two directions—is the increasing use of gas stoves and gas fires, which is a rapidly increasing use, undoubtedly; and probably in the use of briquetted fuel, if the right fuel could be got: I mean to say if a patent fuel of the right quality could be made for domestic purposes, I think it would lead to very considerable economy.

9538. Then you think there is ample room for invention and ingenuity in regard to designing a fuel suitable for domestic purposes?—Yes, fuel which would be of constant uniform quality. I think most of us, as householders, find that we very seldom for two months running have quite the same kind of fuel burnt in our grates. It is very absurd to my mind to alter grates in order to burn a special fuel, unless you are quite sure that you can always get the exact special fuel, but if you arrived at something like constant briquette fuel in a district, then you might arrive at some proper means of burning it, which you cannot do now when your coal may be changed on every occasion at the will of your coal salesman.

9539. And changed as regards size—your cellar getting exhausted?—As to the quality of the coal supplied.

9540. (*Mr. Bell.*) You do not hope for any substitution of stoves for open fires?—I am afraid on that point my opinion is not worth any more than that of the man in the street.

9541. (*Mr. J. S. Dixon.*) Our object is to see what saving in the resources of the country can be made in the matter of coal consumption. You eliminate railways from your wasteful uses, I understand. Can you tell us what consumption of coal per horse-power goes on in locomotives?—No, I am afraid I cannot.

9542. My idea is that they are anything but economical?—I felt that the whole of that question was so very much mixed up with the matter of traffic management and railway management and the conditions under which the traffic is carried on generally, that it seemed to me to be a subject which it was rather better to avoid.

9543. Can you give us any hope of effecting any saving in this very large quantity of 12,000,000 or 14,000,000 tons which are used on the railways? What about electric traction?—I would fain hope that electric traction is the traction of the future, but the whole subject is so speculative that I hardly care to touch it. My sympathies are entirely in that direction, of course.

9544. You do not go the length of saying that any economy can be made at the present moment in regard to consumption on railways?—Not for the moment. I only suggested that it was one of the less obvious fields for economy.

9545. Is it your opinion that poor qualities of coal, high in percentage of ash and probably of sulphur, can be used in the Mond producers?—Yes; there is no restriction in that direction.

9546. It is a question of getting rid of the ashes in an economical way?—Yes; you mean permanently disposing of the ash as it comes from the producer.

9547. There are a great many seams of coal which are not now being worked, because they contain perhaps 8 or 10 per cent. of ash, but which can be worked very cheaply. Can coal of that quality be utilised in the producers?—Certainly.

9548. Then you speak of the manufacture of pig iron. Is there not a possibility that pig iron can be produced by the direct application of gas by some blowpipe arrangement?—I do not know enough practically about iron manufacture to say, but to a chemist and metallurgist it seems not at all an impossible idea. I could not go further than that.

9549. Then may I take it generally from your evidence that you look to the chief economy being obtained by the production of gas and by direct consumption of gas in engines instead of steam?—Gas produced from all sorts of coal by the appropriate producer.

9550. And you would do away with boilers altogether?—Yes.

9551. That is where a great saving is to be made?—It is obviously the largest saving possible at the moment.

9552. That also would obviate the smoke difficulty?—Yes.

9553. (*Sir George Armytage.*) That is, not only for stationary engines, but I see you are also hinting at it with regard to steamboats?—Yes. I am afraid that was rather a speculative suggestion, but still it may come—it is a possibility.

9554. (*Professor Dixon.*) What is the largest power gas engine that you are familiar with?—800 horse power.

9555. How many cylinders?—With two cylinders; it is the double cylinder.

9556. Of about 400 each?—Yes.

9557. (*Mr. Briggs.*) You mentioned that the Glenboig Company were using producer gas. Is that something in the nature of a Hoffmann kiln or something special?—I think it is some modification of the Hoffmann kiln.

9558. Have they been in the habit of using Hoffmann kilns before, or did they go from the wasteful open kiln with the large coal direct to gas firing?—I do not know.

9559. You mentioned also that the difficulty of getting a reliable supply of coke in sufficient quantity was one drawback to the Dellwik process of producing gas. I should like to know whether a hard coke, although it might be a hard coke with a higher percentage of ash than that produced from blast furnaces, would be suitable for that, or whether the soft coke from gas works, say, is really more suitable *per se* in its mechanical qualities?—No, I think there is no essential advantage in the soft coke; it is a mere matter of adjusting the blast to suit the character of the coke. It is simply a question of price.

9560. So that if a coal could be found that would be cheaper and that could be worked up in residual coke ovens, it would then form a very cheap way of making coke, if it were a coke which could be used in that way. Although it would not be good enough and would have too much sulphur for a blast furnace, it would not be debarred from use at all, although it was made in a coke oven instead of in a gas works?—No, there is no inherent disadvantage in that. The one thing that is necessary for the Dellwik generator to give it a chance is that the coke should not contain too much water. One of the serious troubles in working with this plant at first was to get the maker of coke to quench in such a way as to keep down the water contents of the coke to a reasonable percentage.

9561. Is 4 per cent. or 5 per cent. too much?—4 per cent. or 5 per cent. is as much as we could reasonably hope to get it to now.

9562. 4 per cent. or 5 per cent. can be got with reasonable care?—Yes.

9563. Have you formed any opinion with regard to the distribution of Mond gas, we will say, from some large central establishment, as to whether it would be cheaper to turn the power at once into electricity on the spot or to attempt a large distribution of the gas?—I should think the distribution of the electricity would be more satisfactory in anything like a widely spread distribution.

9564. It would be more manageable, I suppose?—Very much more.

9565. And for a long distance it would be very much cheaper than the large gas mains, would it not?—I am not a sufficiently practical electrician to say, but I should think probably it would be.

9566. You think that is the most hopeful way of Mond gas becoming useful for very many industries—say a number of small industries generally?—That is my personal opinion.

9567. You spoke of the efficiency of the blast furnace being improved by the greater height, but I think it is more a question of efficiency in labour cost, and so on, than in regard to consumption, is it not?—I should think that is so.

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Mr. G. T. Beilby.

28 Jan. 1903.

9568. From the point of view of saving of waste, I believe there is no improvement; but the American principle is that they still keep the same amount of coke per ton of pig iron produced, though they return enormously more to the furnace ?—Yes.

9569. So that, from our point of view of economy, there is nothing much in the blast furnace to be hoped for?—No; and I think that was Sir Lothian Bell's view in a paper which he read.

9570. But is it not claimed that a good many years ago they had got to nearly the best point? I do not know that anything better has been reached?—That is so.

9571. There is one matter with regard to domestic consumption which you perhaps wisely kept clear of. That consumption covers an enormous quantity of coal, and I suppose one would be right in saying that by central heating in buildings probably a great deal more than half of it could be saved ?—I think that would be quite a safe estimate.

9572. So that in that item alone, as far as saving goes, if there were necessity for it and if the people would do it, there is a saving to be made of some 20,000,000 tons of coal?—It is quite possible, if coal becomes sufficiently dear.

9573. (*Sir George Armytage.*) Are you speaking of that as applied to fireplaces, or with regard to hot water heating?—By hot water heating and stove heating, and by heating large buildings centrally.

9574. (*Mr. Briggs.*) By hot water?—Yes.

9575. (*Sir George Armytage.*) That is to say, by distributing heat?—Yes.

9576. (*Mr. Briggs.*) Then you suggested that suitable briquettes would rather obviate the difficulty, more by enabling small to be used for domestic purposes than with regard to any actual saving, I take it?—Yes.

9577. Have you considered that if that were so you would have either to burn more expensive fuel by breaking up the coal which is at present used for domestic purposes and manufacturing it, or you would have to use the small or refuse from the present seams, washed and prepared and made into briquettes—one or the other?—That would be necessary.

9578. My point is that at present a great number of collieries are worked almost exclusively for domestic consumption?—Yes.

9579. Where would that coal be used? In other words, where would the small be produced from, unless that coal were used in domestic fires ?—But I suppose a great deal of the coal that is at present used in domestic fires—these 36,000,000 tons—is not of very first-rate quality at all; I suppose a very large part of that is coal which would more properly be used for industrial purposes.

9580. I think, generally speaking, if you were to analyse it you would find a better heating power in it than in the average industrial coal—not better than the best coal, such as Welsh or South Yorkshire hard coal, but as compared with the vast bulk of coal that is used for industrial purposes it would be a great deal purer, and would have better calorific power. It would mean the shifting of such an enormous quantity of fuel that I hardly see much hope in your suggestion myself ?—No, I think it would be only partially effective, at any rate.

9581. If an alteration of the means of heating could be brought about by exhibitions, examples, precept, law, or anything else, there would be more hope of a saving in coal?—Certainly; and I think that applies very much to all the possible savings in all directions. It seems to me that what is needed by the public, both the ordinary private consumer and the industrial consumer, is to have put before him in the very simplest possible way, the simplest and clearest statistics as to what he ought to be getting out of what he is burning, what he is wasting, what he may possibly save, and at what cost he can make these great savings. I think those figures would require to be put in an exceedingly clear and unembarrassed form both for the ordinary private consumer and the industrial consumer. I think that would be a very valuable thing, if the information could be officially and permanently brought before the consumers.

9582. If we were to take the cost of heating, say, a large Swiss hotel, and compare it with the cost of heating a similar building in England, where the temperature is very much higher, I should imagine we should find that they do it in the one case for a third less cost than in the other ?—Yes, I think it is well within that figure.

9583. I know that a small quantity of gas coke with a central heating apparatus is sufficient for the Swiss hotel, and that it heats it, as far as temperature is concerned, better than our method?—Of course, the question of open windows comes in, because in Swiss hotels perhaps they are not so fond of open windows as we are.

9584. Where there are English people I think they generally open them?—Yes.

9585. (*Mr. Sopwith.*) In connection with the superheaters, you mentioned that they were applied to moderately large engines. I do not know where you would like to draw the line. I think it is partly covered by your saying that the engines for highly super-heated steam would require special construction. Do you mean by that that the expense incurred in substituting the engines necessary to deal with highly super-heated steam is likely to interfere with the introduction ?—I should think that any manufacturer who is to consider the replacement, for economical reasons, of one engine by another, if he comes to face seriously the question of a new capital expenditure, would probably extend his improvement to gas engines, and he would probably find that the economy was going to be so very much greater with the gas engine that he would put aside the superheating; but in other cases the manufacturer might take the course of putting in new super-heaters.

9586. How would you define a moderately large engine?—I have in my mind engines of a few hundred horse power.

9587. With respect to the producer gas, it is obvious that if it can be used directly, it is better to use it?—Do you mean to use it while it is still hot?

9588. No, not merely hot, but I mean to say not stored? — There is no object in storing it, because a modern producer is such a very elastic machine that you can work without storage, practically.

9589. Do you mean to say that you would be able with a producer to regulate the very intermittent work?—With two producers, certainly.

9590. Yes, but you would require a double plant?—I think you might require a double plant, with very intermittent work.

9591. Some work is very intermittent; for instance, with colliery work you might require three plants?—Yes, but I do not think gas storage is ever the way in which you can meet fluctuations of a large installation with power gas. It is such a very poor gas that the storage becomes a most serious thing.

9592. I suppose there would arise a question as to the depreciation of the gas from standing in the holders, would there not?—No, the gas would rather improve, because it is very desirable to get all the water out of the gas that can possibly be got out of it; you want as dry a gas as possible when it comes to be used in the engine, and the storage would rather help that than otherwise.

9593. With regard to the advantages of using the gas direct and using it for some other means of distribution —electrically or otherwise—it might be an advantage if you had a producer regularly at work, by which you would be able to use a regular quantity of gas; or, rather, I should like to put it in this way: in regard to intermittent work, you have dealt with that to a certain extent by saying that you would have two plants, but I was going to take it supposing you have only a single plant and you have storage, you might require very extensive storage to meet the cessations of work, but you might do with a smaller storage plant and keep working regularly and utilising the gas for uniform production of power, such as electrical power?—You see the producer is an exceedingly mobile instrument; you can start work within a very few minutes; you have merely to start the blower, and it is set going.

9594. I think your answer with regard to having the two plants covers it?—Yes, the advantage of having two plants is that if you have very continuous work you have intervals for stopping to clean the producer; it

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is just the general advantage which stand-by plant always presents.

9595. I understood you to say that there is very considerable difference as between very small coal and large coal—that is, coal of presumably the same quality; do you mean to say that that is on account of the mechanical condition and getting between the bars and being carried off?—Yes.

9596. You do not mean that the quality of the coal is depreciated?—No, not at all; it is purely from a mechanical point of view.

9597. (*Mr. Bell.*) You remark in your proof that producer gas draws its supplies of raw material from the largest and cheapest sources of fuel. You refer to slack, of course?—Yes.

9598. Do you consider that slack is the largest source of fuel?—Well, when one is in a position to take slack from almost every district, it does become a very large source, it seems to me.

9599. We have had a great deal of evidence with regard to the method of dealing with and making more workable this slack coal, by dividing it into different sizes and pieces—Yes.

9600. I suppose in producing gas from slack you would consider that slack includes pieces of an inch or ¾ of an inch square?—"Slack," in the sense in which I was using the word, does include a certain amount of rougher coal.

9601. But if it included only pieces of ⅛ in. size, it would be equally valuable, would it?—Yes, I think one might say it would be equally valuable.

9602. The success of this kind of plant does not, of course, entirely depend upon having coal at such a difference in price as is exhibited to-day, for instance, between the price of slack and the price of large coal?—Oh, no. I do not know what you would put that difference at, of course.

9603. I mean that, of course, you would have at the present time, and probably for a long time to come, the advantage of being able to buy slack coal at a very low price, compared with the price of best round coal; therefore you can enjoy that advantage in price; but if we progress in the future, and in the immediate future, in fact, at the same rate as we have been progressing during the last few years, according to the evidence we have received, we shall raise the price of slack coal, or at least of 75 per cent. of that slack coal, almost to the value of large coal?—Yes.

9604. And in that way you would have to pay more for your coal for gas producing?—I think I have been assuming right through that that would naturally take place; in fact, I assumed that it had already almost taken place by reason of the washing processes and sorting processes which have brought up the value of slack, nuts, and so on, to a point that is not very far removed from that of the coal from which they are made.

9605. I notice that in prospectuses of these things a great deal is made of the low price at which slack can be procured?—Yes.

9606. But if the consumption of slack were to go on at the same rate for the next few years, I think we should have the price of slack raised very much more than it is relatively to-day?—Yes, I quite anticipate that when producers become more generally used, probably the rough coal, the slack and everything, will be taken then, and the whole output will come straight to the producer.

9607. (*Mr. Briggs.*) That is to say, at an average price?—Yes.

9608. (*Mr. Bell.*) And the whole output will be more valuable as a gas producer than the slack, I take it?—Yes.

9609. (*Mr. Brace.*) You say that if the life of the Welsh steam coal supplies is to be prolonged it will be necessary to find some substitute. Then you have stated in answer to questions that the substitute you suggest, or one of the substitutes, is briquettes?—Yes.

9610. I understand that briquettes made from coal are what you have in your mind?—I had in my mind briquettes made from a great variety of coals, but as a necessary preliminary to that, the qualities of each special coal—the coal of each special district and of each special seam—would have to be examined for its appropriateness for the work of making it into briquettes. But I consider that by the use of distillation processes in addition to the washing and sorting processes, one would get a very much wider command of materials from which first-class briquettes might be made. That is a point which I desire rather to press.

9611. (*Mr. Sopwith.*) That is, by partial distillation of the coal beforehand?—Yes.

9612. (*Mr. Brace.*) But in Welsh steam coal you have coal of the highest quality for steam purposes?—Undoubtedly.

9613. How do you propose to make briquettes from an inferior quality of coal anything like a substitute for that very high-class coal?—I do not think we are very likely to reach the standard of the very highest quality of steam coal: but it seems to me that short of that—even a considerable percentage short—there would be a very good outlet for the fuel that had most of the good qualities of the Welsh coal: that is to say, its freedom from smoke and its bunker qualities—that the difference of 10, 15, or 20 per cent. in its thermal value is not necessarily a prohibitive difference if it becomes desirable to replace it. I have always understood that one of the most serious difficulties in the way of replacing anthracite by bituminous coal was the smoke question, especially for naval purposes; and I had chiefly in my mind the preparation of a thoroughly satisfactory bunker coal, thoroughly satisfactory also from the point of view of smoke and as using up small.

9614. (*Sir George Armytage.*) The best substitute?—The best substitute, and necessarily, of course, having the highest calorific value that you could obtain along with those qualities.

9615. (*Mr. Brace.*) If briquettes are the best substitute you can have, briquettes made from South Wales small steam coal would be the best kind of briquettes, I assume?—There seems to be a probability that it would follow, but I do not think it necessarily follows, because you may be able to bring the other qualities of coal, by suitable heating and preliminary treatment, to a point at which they will be even more valuable for briquette making. You see, with the small of the Welsh coal as it stands, there seems to be hardly any other alternative but that you should do what is at present being done—namely, cement it together with a certain percentage of pitch and tar, but the cementing together with pitch and tar is not a very satisfactory process from the smoke point of view.

9616. I agree. Therefore, I had in my mind that if we could hit upon the conditions at which this incorporation of the different materials could be made, either at a high temperature or otherwise, so as to avoid, possibly, the importation of this smoke producing pitch or the reduction of it to a minimum, we should then have a better briquette fuel than we at present possess.

9617. Agreed; but does that really alter the position? We start with Welsh coal as being the best; a briquette is to be the substitute. I suppose it is my want of knowledge, but I cannot see why, if the briquette is to be made of small coal, the small coal from this class of very dry steam coal will not make a better briquette than the small coal from an inferior class of coal?—By existing methods, certainly, but I was merely looking forward to the perfecting of existing methods.

9618. Still, the perfecting of the method would apply to the South Wales small coal as well as to any other inferior small coal, would it not?—That depends entirely upon how its qualities turned out when they came to be investigated, with a view to getting at the most suitable means of incorporation.

9619. Briquettes are largely used for locomotive purposes in France, Spain, and upon the Continent generally, are they not?—That is so.

9620. There are two kinds of small coal in Wales; there is the bituminous small, suitable for coking and for the securing of bye-products, and there is the dry small coal, which is looked upon at this moment largely as being useless. May I put it to you that the bituminous small coal could be used for coking and for securing bye-products, and that the dry small coals that would not coke could be used for the making of briquettes?—I think that is exceedingly probable, but, of course, the dry small coal will probably require a greater amount of cementing material than the more bituminous coals.

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Mr. G. T. Beilby 28 Jan. 1903.

9621. Agreed; but at this moment you make a point upon which I quite agree with you. You say that if the life of the Welsh steam coal is to be prolonged, it will be necessary to find some substitute. There are hundreds of tons or thousands of tons of this best small coal wasted in the gob every day, and what I am really trying to arrive at is this: If you were a member of this Commission, with your knowledge that briquettes are the best substitute for this high-class coal, and also with the knowledge that all this coal is at present being wasted, would you feel justified in recommending that that coal should be brought out, instead of being wasted, as it is at the present time, and gobbed?—I think it would obviously point to that being one of the very first directions in which the renewed efforts to make briquettes should be directed. At the same time, I think that a masterly treatment of the subject would not be complete without taking into consideration all the coals throughout the kingdom as possible briquettes materials.

9622. Agreed; but at the present moment in Scotland, the north of England, and practically all over the Midlands, we have the coal brought out. The coal is filled by way of run of mine?—Yes.

9623. And it is only in South Wales that you have this great waste of small coal?—Yes.

9624. Therefore, while it is correct to take the general condition of the coal of Britain into consideration, you have here the one great waste which requires dealing with?—Yes.

9625. Now, although there is this bituminous coal, which is suitable for coking and for the securing of bye-products, there does not seem to be much speculation in the placing down of ovens or in the placing down of the necessary plant for securing bye-products. I note that in your address at Newcastle, in 1899, at page 19, you were speaking about the difficulty of a fluctuating market, and you said, "On these grounds, then, I believe that if the ammonia producer can get the equivalent of nitrates and sulphate fairly recognised, he may safely, and even with advantage, push up his output to five times its present dimensions in the confidence that it is not he who will suffer in the long run." Would there be any danger if the coking business was developed and bye-product plant put down, and you had very much more ammonia, if you like, or of bye-products generally, than you have at present—would there be some danger of bringing down the price, because of the increase in the supply, to a point that would not make it a profitable undertaking?—I think that is very unlikely. You see, in competition with nitrate of soda, which is the great rival of sulphate of ammonia, the quantity is at present so enormously in favour of nitrate. I think the importation of nitrate is considerably over 1,000,000 tons per annum to Europe—and the production of sulphate of ammonia at present, I think, is something about 200,000 tons—it is not one-fifth. I believe there is plenty of room for the relative proportions between sulphate of ammonia and nitrate to be enormously altered before there would be any serious fall—consequent upon that, I mean—in the price of sulphate of ammonia.

See Appendix II.

9626. So that to your mind there would be no danger whatever in increasing the supply?—No; I think there is more danger at the moment, unless the supply is very quickly increased, of sulphate of ammonia going to very extravagant prices, which is not for the benefit of anybody, because the gas works' production of sulphate of ammonia has evidently arrived at its maximum, and is not showing signs of increasing, but will probably before long be on the way down. So that, unless other sources of supply of sulphate of ammonia are obtained, I think the prices will go higher even than they are now, and I do not think it is desirable to maintain even the present prices.

9627. You say, in regard to the solution of the problem which has to be solved, "I consider that this problem"—that is, the problem of briquettes—"would be best worked out by a small committee of experts familiar with the conditions under which destructive distillation and combustion processes are being carried out in the most modern works." What kind of committee of experts have you in your mind? Is it a Committee formed from this Commission, or a committee altogether apart from this Commission?—I am not sure whether this Commission includes all the kind of experts that I had in my mind. It would be eminently desirable, I should think, that the Committee should be within this Commission, but at the same time it would involve an enormous amount of detailed study of matter which is foreign to the ordinary work of a Commission as far as I know it.

9628. Then your suggestion really amounts to an inquiry being conducted under the auspices of this Commission, but with some experts added to it who are not members?—I should think that would probably be a practical way of working it out.

9629. (*Sir George Armytage.*) Or, rather, what I understand you to mean is that it is necessary that this matter should be inquired into by experts, whether this Commission has power to appoint them or to recommend them or not?—Yes.

9630. (*Mr. J. S. Dixon.*) I do not know whether your views with regard to the duration of our coal resources are put prominently enough on the notes. I suppose we may take it as your opinion that as the more valuable and cheaper coals get exhausted, and coal rises in price, there will be a great many economies invented to meet the dearer coal to which we may look forward?—I think the stimulating effect of a continued high price, or a continual rise of price would be simply enormous, or almost incalculable; because in the past we have never had high prices continued long enough to affect more than the enterprising manufacturers.

9631. Even when the price rises temporarily it gives a stimulus?—It gives a stimulus, but that stimulus does not reach the average manufacturer sufficiently. I believe that if we had had the high prices maintained for say, three years, it would have done an immense amount of good with regard to promoting economy.

STATEMENT sent in by Mr. BEILBY, in answer to Question 9430.

(1) Costs of fuel per unit of electricity sold, being averages taken from 167 central stations (steam power) in the United Kingdom.

(Abstracted from the "Electrical Times," Table of Electrical Supply Costs and Records, December 4th, 1902.)

Cost per unit sold of coal and other fuel:—

Limited Companies (1900-1902).

Metropolitan—
15 Stations. Average Cost Fuel - 1·032d. per unit.

Provincial—
37 Stations. Average Cost Fuel - 1·063d. per unit.

Local Authorities (1900-1902).

Metropolitan—
7 Stations. Average Cost Fuel - 1·076d. per unit.

Provincial—
108 Stations. Average Cost Fuel - ·886d. per unit.

For all above Stations (steam power).

167 Stations. Average Cost Fuel - ·952d. per unit.
Equivalent to about 0·809d. per unit generated.

Compare this with the actual cost for Mond gas of ·048d. per unit generated with gas-engines running continuously at Winnington.

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(2.) COAL CONSUMPTION AND ECONOMY.

	Consumption in Millions of Tons.	Saving in Millions of Tons.	Means of Economy.
Railways	12 to 14	5 to 7	Gas generators and engines, and electro motors and electric traction.
Steamers	6 „ 8	—	
Factories	40 „ 45	20 to 30	
Mines	10 „ 12	5 „ 7	
Blast furnaces	16 „ 18	2 „ 3	Gas engines and recovery ovens.
Iron and steel	10 „ 12	2 „ 3	
Other metals	1 „ 2	—	
Brickworks, potteries	4 „ 6	1 to 2	Gas generators and coke.
Glass works, chemical works			
Gas works	14 „ 15	5 „ 8	Gas cooking and heating briquettes and coke.
Domestic fires	30 „ 36		
	143 to 168	40 to 60	

(3.) The chief difficulties which stand in the way of rapid and extensive adoption of these economies are :—

(1.) The natural inertia of individuals and of Corporations.

(2.) The large capital expenditure involved in their adoption.

The inertia may be overcome by one or other of the following motives.

(1.) The fear of making heavy losses under existing conditions.

(2.) The hope of making larger profits under new conditions.

(3.) The influence of example. New ideas are contageous in industry as in other departments of human interest.

(4.) In the case of railways, the difficulties referred to apply with much force; inertia and an already overloaded capital account will probably cause railways to lag far behind other branches of industry in the adoption of the most economical methods of producing power.

The British railways own about 20,000 locomotive engines, many of which are of antiquated design, but all of them fit to do a day's work of a fairly creditable kind. These locomotives could probably not be replaced at an overhead figure of £2,000 a-piece, so that their capital value may be taken as not less than £40,000,000. But this is not all, for in order to reach the full economy of fuel and to reduce the coal consumption from 14,000,000 tons to 4,000,000, 20,000 miles or more of permanent way would need to be adapted for electric traction, while the outfit and organisation of locomotive building and repairing sheds would need to be completely altered. It may be taken as practically certain that the cost of coal will need to be permanently on a much higher level before any general replacement of steam by electricity will take place on railways.

In coasting and in ocean-going steamers, the possibility of any important economy is in the meantime problematical.

(5.) When it becomes generally recognised that the power required in mines and factories can be obtained at one-fourth to one-half of its present cost, the transformation from steam to gas will proceed very rapidly. The prospects of increased profit are sufficiently attractive to overcome a good deal of inertia, and to amply justify the necessary expenditure of capital. The collective capital required is large if steam plant of 5,000,000 i h.p. is to be replaced by gas generators and engines. At the rate of £12 per i h.p. it amounts to £60,000,000 But if the capital is large, so also is the economy to be realised. A saving of £5 per i h.p. year may be confidently taken as well within the truth, and this would amount to £25,000,000 per annum. This magnificent sum would provide for the capitalist, the manufacturer, and even for the middleman, a very handsome reward. Nor should it be forgotten that the capital expenditure of £60,000,000 includes remuneration and profit for the constructing engineer and his employees.

(6.) It is probable that in so far as the economies which are possible in the production of heat for industrial purposes are carried out, some of the capital and other responsibilities of the preceding division will be covered by this; that is to say, if the owners of blast furnaces and coke ovens choose to become suppliers of power, either in the form of gas, or as electric current, the fuel thus saved will proportionately reduce the direct consumption for power purposes.

(7.) The econony which may take place from the more general replacement of raw coal by gas in brickworks, potteries, chemical works, and other factories, will be of more importance to the individual manufacturers than to the nation at large; but the resulting abolition of the industrial smoke cloud will be even more widely appreciated than the saving of 2 or 3 per cent. of the national coal bill.

(8.) Economy in the domestic consumption of coal is mainly to be expected through the increasing adoption of central heating in houses, the open fire, or its substitute the radiating gas fire, being merely used as supplementary to the general warming by hot water pipes or by stoves.

A powerful impetus would be given to reform in domestic heating if judicious legislative pressure could be brought to bear on the producers of black smoke. The architect, the builder, and the householder must be forced to realise that this is a question which they must deal with.

The cheapening of town gas and the preparation of really good briquettes for domestic stoves and fires would greatly facilitate the necessary reform.

(9.) In conclusion, I am convinced that the industry of the country, its transport service, and its domestic life might all be carried on in a more perfect and efficient way, and with greater comfort and seemliness, with a coal consumption of less than two-thirds of the present amount, and I am satisfied that no real financial barrier stands in the way of this desirable reform.

Colonel S. A. SADLER, M.P., called; and Examined.

9632. (*Sir George Armytage.*) Are you a member of Parliament?—Yes.

9633. Your evidence relates to Middlesbrough and Durham, and you are a colliery owner?—Yes.

9634. Will you kindly give us your evidence first of all with regard to the cleansing inferior kinds of coal?—Inferior coals are nearly always vastly improved by the simple process of what is termed "picking." The coal is carried on a travelling belt, which should be of ample length, and well lit from the roof. Boys standing on each side of the belt at short distances, pick out the stones, shale, etc., as the coal passes along. Many poor, unsaleable seams can be made into a good marketable product by careful adequate treatment in this way. I know of many coals now condemned that might be made a marketable product by a very careful and, I may say, a conscientious picking.

Coal washing is now rapidly becoming general for separating impurities, but until recent years few colliery owners would face the expense, the trouble, and, it may be added, the mess that its adoption involved.

(1.) The forms, designs, and methods of coal washing are very numerous, though they are all based on the principle of removing the *d bris* by taking advantage of the

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Colonel S. A. Sadler M.P.

28 Jan. 1908.

low specific gravity of pure coal—the impurities being invariably much higher.

(2.) It is not more than 25 years ago that coal washing began to be employed to any extent—impure coal seams were previously discarded; the first apparatus being simply a copy of that used for purifying ores. It was not by any means economical, on the contrary, in many instances the washing was done crudely, and in every case wastefully.

(3.) At the present time, so perfect are the mechanical appliances that, although prodigious quantities of coal are treated in single installations, the loss of coal is quite inappreciable. I am speaking there of the most modern form of coal washer. It is not generally known that the small and dust coal is much the purest part of the whole. The explanation, however, is extremely simple. Any crushing or abrasion in handling the coal naturally affects the softer parts of the mass most. Coal is much the tenderest part, and therefore suffers first, being "crumbled" down out of all proportion to the whole.

(4.) Manufacture of coke.—The annual production of coke for metallurgical uses in Durham and Northumberland and on Tees side is about 5,000,000 tons. The latter place, I may say, is almost a new factor in coke producing, at any rate, during the last 10 years.

(5.) Coke ovens without utilising gases.—It is claimed that the old-fashioned Beehive ovens, with a direct opening at the top for the gaseous outlet, give the hardest, brightest, and most refractory coke. The yield of coke on the coal used, however, is always lower than would be got by more scientific methods of working them. For instance, coke ovens of this kind will yield at least 5 per cent. more coke on the coal by strict regulation of the air inlets, throttling the exit on the top, but especially if the air before admission into the oven is heated by passing through flues round the top or sides of the oven.

(6.) Coke ovens with gases utilised for heating.—A great economy is effected by applying the red-hot gases from the ovens for raising steam. Nearly all large coking collieries avail themselves of this important advantage. A battery of about 35 ovens will provide sufficient heat for a Lancashire boiler 30ft. by 8ft. Each pound of coal put into the ovens will evaporate about 1·2lbs. of water, but, of course, this will depend on the percentage of the volatile matter in the coal. The quantity may vary, but average ordinary Durham coking coal may be taken to give that result. It looks small when it is remembered that the same coal used for firing a similar boiler gives 8lbs. to 9lbs. of efficiency, but it must not be forgotten that the volatile matter in Durham coking coal is about 25 per cent., and it is that portion alone which is available, and then only in respect to the heat left after combustion, which occurs inside the ovens.

(7.) There are many modifications and varieties of ovens belonging to this class, each particular one, doubtless, having some merit, but none gives better coke than the simple Beehive type built with super-heating air-flues—the hot evolved gases passing to suitably arranged steam boilers. As to the yield of coke on the coal, however, much depends on the skill and attention of the workmen. How important this last point is is not generally appreciated. If by careful management the yield is improved 2 per cent.—there are few collieries where this could not be effected—it represents on a 60 per cent. ordinary yield 1-30th more, which, with coke at 15s. per ton, is 6d. per ton, or £50 per week on an output of 2,000 tons. The increased quantity of coke from the same coal would be about 3,500 tons per annum in this instance; but a greater result could be attained in most cases.

(8.) A modern oven in some favour is the long, narrow rectangular kind, about 30ft. long, 2ft. wide, and 8ft. high, with super-heating air-flues and mechanical appliances for regulating precisely the air being admitted. I may say I am speaking of the Coppee type of oven. The coal is coked by heat from flues on both sides. A much higher percentage of coke on the coal is obtained in them; but whether it is due to the mode of coking, or to the quenching outside of the oven—probably to both causes—the coke is darker than the Beehive quality, and lacks the silvery lustre which characterises the latter.

Ten per cent. and even greater yields are got in these ovens compared with Beehive ovens. Undoubtedly, some of this saving is the result of a more scientific and automatic admission of air, but it largely comes from the occlusion in the body of the coke of carbonised tarry bodies, owing to the rapid coking by the side flues. In the slower processes these tarry matters are distilled off, and are burnt with the other gases. The carbonisation goes on so rapidly that the tarry bodies become carbonised before they can escape. An important advantage gained by high coke yields, besides the saving of carbon, is that it reduces the percentage of ash—a serious factor in the value of coke. It will be seen that the more carbon is lost, the more the ash contents must increase.

It may be accepted as an axiom that the heat developed by the hydro-carbon gases from the coal is more than sufficient to coke it, and no further carbon is required. There are technical difficulties in exactly hitting this point, but they may, to a large extent, be overcome with patience, regularity, and intelligence.

(9.) A grave source of loss in "coking" is the considerable quantity of fine breeze, commonly called "ballast," which invariably accompanies it. Of very little, if any, marketable value in that state, many schemes have been devised to utilise it for fuel, so far with little success. Chemically it is little inferior to the coke, of which it originally formed a part. I have seen many efforts made to make it into briquettes. The pitch binds it together, and as a briquette it looks quite perfect, but when it is put on the fire, and the pitch becomes heated, the whole thing tumbles down into a fine friable mass all over the fire. It does not hold together, as in the case of coal. Efforts to make it into briquettes have failed, as also the attempt to burn it by injecting it into the fireplace by forced draught, after grinding to dust. Large heaps of mountainous dimensions of this fine coke may be seen at most coking collieries.

Whilst means of profitably disposing of this "ballast" have failed, remedial measures, lately come into vogue, are successfully preventing its formation to a considerable extent. Both damping the coal and crushing it very fine materially lessens the quantity of breeze; but compressing the damp fine coal into a compact mass before it enters the oven almost completely remedies the evil, as well as realising a valuable saving. Taking this at a small figure, say of 3 per cent., it represents a large quantity of fuel over a year.

Of course the coking quality of the coal has a marked influence on the quantity of breeze or "ballast" made.

Coke ballast is an excellent substitute for sand in mortar, concrete, etc.; from its lightness and absolute chemical permanence no other material can compare with it for the purpose.

(10.) Coke ovens with recovery of bye-products.—There are several well-known systems of this class of oven, differing chiefly in the methods of heating and in the details of construction.

The first instalment in this country was made in 1883, by Messrs. Simon-Carvès, who were the origina inventors of this manner of coking.

For many years a remarkable prejudice existed against the coke from these ovens, and few iron smelters would look at it. The last decade, it is gratifying to find, has brought a gradual but sure change of view; not only have objections been overcome and the coke passed into everyday use, but a good many iron works have now erected, and are erecting, plant of this type for their own purposes. This form of coking is, in my opinion, likely to supersede all others, and is likely to play an important part in cheapening the cost of iron and other manufactures where coke forms an integral part.

(11.) The ovens are about 30ft. long, 1ft. 8in. to 2ft. wide, and about 8ft. high. I may say the width of these ovens depends upon the quality of the coal. With dry coal the oven should be narrow, but fat coal will stand a much wider oven. To all intents they are a gas retort on a large scale, "carbonising" about 5 tons of coal each charge. They are heated by flues on the sides and bottom; the hot gases, after traversing the flues, are employed for raising steam.

The gases emitted during the carbonising of the coal are drawn off by exhausters to be dealt with in a "residual plant." The coal tar, ammonia, and benzole

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are condensed and washed out of the gas, and what gas is required is then returned to the bottom flue of the oven and burnt there to supply the heat for the process. There is usually about 35 per cent. of surplus gas which can be made to do duty for lighting, power (gas engines), and for heating steam boilers.

(12) The yield of coke is from 10 to 15 per cent. greater than is obtainable from the same coal in the old Beehive oven. I may say I have some ovens of this type working alongside a number of Beehive ovens, and the average is 13 per cent. more dry coke from the same coal. The coke is denser than the Beehive quality, and a little darker, perhaps, from watering outside the ovens on the bench. This slight defect (a sentimental one, maybe) can be obviated by careful quenching. It has been found that by quenching this coke with a very high pressure of water, so as to, as it were, force the heat out of the coke by the pressure of the water, the lustre of the coke is preserved, and a great deal less water is required.

For metallurgical purposes I think it will be seen by all practical men that the appearance is a sentimental matter. The coke shows a better chemical analysis than that from the same coal treated in the old style of ovens, the ash and sulphur being decidedly less.

In this light it is therefore not surprising that the prejudice so long existing is so far overcome that several well-known blast furnace managers have recently declared they prefer it to any other.

(13) Owing to the density it should have a stronger blast in the furnace, and in every trial where this condition has been complied with the production of iron has been much larger than with ordinary coke in a given time—say over a week or a month or further period. Very many of these experiments have been made in blast furnaces on Tees-side, and invariably with a sufficient blast they give a larger yield in a given time; and it has invariably been found to be equally as efficient in other respects, starting with both fuels perfectly dry. I make a special point of the last few words because some experiments have been made and have been reported in which it has been shown that with this retort oven coke the quantity used has been perhaps half a hundredweight per ton of iron more. but that has always been accounted for by the excess of water in the retort coke. The Beehive coke is "put out" in the oven, and the water all goes off before the coke is drawn. In this case, if the men watering the coke are not careful they are apt to get more water into the coke than there should be, and that accounts for the difference in one or two cases when using this coke for blast furnace purposes.

(14) Showing how refractory retort coke is, and how well it bears the crushing pressure of the furnace, good-sized pieces regularly come out with the slag if the blast has been inadequate. One of the prejudices against this coke is that it was thought it would not bear the crushing of the load in the furnace. It has often been within my knowledge that small portions of this coke have come out with the liquid slag, showing it does bear the crushing, and showing its refractory nature in regard to combustion. It is feared that this would take place too early in the upper reaches of the furnace, and that they would not get it so intact in the smelting zone as they say they do the ordinary coke, but it has been proved very conclusively that that prejudice, at any rate, against this coke was unfounded.

(15) The quantities of bye-products obtained fluctuate with the constitution of the coal, and they are, moreover, influenced by the heats and practice at the ovens. It is worth mentioning here that if these ovens are worked with some little exhaustion on them, it will be seen that any air admitted into the oven would attack the bye-products first and partially destroy them; and that accounts for the very marked variation there is in the production from this class of ovens. I will give you the figures. I may say I make 2,000 tons of coke of this kind a week at one of my collieries, and our average yield is 26lbs. of sulphate ammonia per ton of coal, so that I have put the figures very low. Taking them at a very low yield per ton of coal, they are as follows:—

	Net value after deducting all costs.
	s. d.
20 lbs. sulphate ammonia - -	1 8
6 gallons tar - - - - - -	0 9
1 gallon benzole - - - -	0 4
35 per cent. surplus gas (say 2,000ft.)	0 6
10 to 15 per cent. more coke, say -	1 6
Total gained by retort coking -	4 9

9635. (*Mr. Brace.*) Do you say that you get 10 to 15 per cent. more coke out of a ton of coal in consequence of your bye-product arrangement?—No, it is due entirely to carbonising in a closed retort oven.

9636. (*Sir George Armytage.*) Your point is as compared with the Beehive oven?—Yes, where the combustion takes place inside the oven. These are eloquent figures, and comment seems superfluous; but it is appalling to contemplate the loss the country is sustaining by wasteful coking processes. It is, indeed, nothing short of a national reproach. Taking Durham and Northumberland alone—together they make every year say, 5 million tons of coke. Admitting the minimum increase of yield by retort ovens at 10 per cent., that means 500,000 tons of coke at 14s. per ton, or a loss of £350,000. I have put it at 1s. less than Beehive coke so as to be well within the mark—14s. per ton, or a loss of £350,000. If we add to this the value of the bye-products, namely, 3s. 3d. per ton on the 6,660,000 tons of coal required to make 5,000,000 tons of coke, roundly, £1,100,000, we get a total of £1,450,000 a year, which the two counties would save were all the coke produced in retort ovens.

Assuming that about 10,000,000 tons of oven coke are produced annually in Great Britain, the national saving would be £2,900,000.

(1) Processes for making cake out of coal usually considered non-coking.—Coal which will not coke in a Beehive oven will often do so in a retort oven, the carbonising being more rapid, and the hydro-carbons, which have a vital bearing on the coking operation, are utilised before volatilisation is possible, the considerable depth of the coal probably helping.

5 to 10 per cent. of pitch has been found to afford effective cohesion to dry coal, giving an excellent coke in "quick" ovens, though very dense and always dark. The method is too costly for common use.

The simplest and most practical way of making coke out of dry coal is to mix with it, in such proportion as may be necessary, a "fat" or rich coal. Excellent results are obtained in this way, the advantage being of a mutual character; for whilst dry coal will not coke, "rich and fat" coals by themselves always make a spongy mass. Satisfactory results can only be got by most intimate admixture of the coals, and it is essential that they should be ground fine.

An interesting test for ascertaining the coking efficiency of coal is to gradually add sand to it until the coal ceases to coke. By this very simple experiment the proportion of dry coal that may be safely mixed with the bituminous coal is readily calculated.

(2) Manufacture of Briquettes.—Although several factories have been established, the manufacture of briquettes has not flourished in the North-East of England. Several causes have probably contributed to bring this about:—(1) The facilities for shipping small coal to the Continent, where briquettes are made on close scientific lines. (2) The large use of small coal for coking. (3) The rather considerable market for it for fuel for salt and chemical works, but especially for calcining iron ores and limestone. (4) The comparatively low price at North-East ports of screened coal, with which, of course, briquettes have to compete. The fourth cause, perhaps, is more important than the other three. You see, screened coal in the North-East ports to-day is worth about 10s. 6d. to 11s. per ton.

9637. (*Mr. Brace.*) Would that be f.o.b.?—F.o.b. on Tyne. Durham coal I am speaking of, of course, not Northumberland. It would be practically impossible for briquettes to compete with a price like that. I am speaking of screened coal, and that is what briquettes would have to compete with.

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Colonel S. A. Sadler, M.P.

28 Jan. 1903.

9638. (*Sir George Armytage.*) I do not remember that you have said anything about compressing the coal before coking at all?—Yes, I say both damping the coal and crushing it very fine materially lessen the quantity of breeze; but compressing the damp fine coal into a compact mass before it enters the oven almost completely remedies the evil as well as realising a valuable saving. That can be done in the Beehive type of oven if they are made to receive the coal in a compressed block.

9639. Is there anything else you would like to add in connection with compression?—The advantage of compression in the first place is this, you can get more coal into an oven in a charge, but they claim also a bigger yield of coke. I think that is largely due to the less ballast that is produced—I think almost entirely to that.

9640. (*Mr. Sopwith.*) Is the coke not more dense?—The coke is a little denser, but not so much as you would think, especially with a coal containing over 25 per cent. of volatile matter. In the first instance there is about 10 or 12 per cent. of water, and this boils up in the oven and causes the coal to settle down in the oven very solid. When the coking process begins it is lifted up like dough in the oven.

9641. The density would vary with different classes of coal?—Yes, very much. I recommend the use of a fat coal and dry coal. That always gives you a dense coke curiously.

9642. The compressing the coal may vary considerably the subsequent density?—Yes. Of course, compressing dry coal which will just coke and only just coke, will give you a very dense coke; but compressing coal containing a great deal of volatile matter will not give you a very dense coke. The evolutions of the hydrocarbons in the carbonising process lift the coal up in the oven into a spongy mass.

9643. (*Dr. Le Neve Foster.*) What is the great difficulty, do you think, of making briquettes from coke dust?—The one I speak of is the greatest—the difficulty in making it hold together.

9644. Could you overcome that difficulty by greater pressure, do you think?—I do not think so. The hydrocarbons in the coal assist the pitch in keeping the form of a briquette on the fire. As regards the coal in the North of England, it cokes when it is put on to a fire, and the briquettes made from that coal are usually very good, and retain their shape very well. In every case where I have seen the breeze from the coke made into briquettes after the brick becomes heated on the fire it crumbles gradually down like a mealy mass.

9645. Have those briquettes been made with great pressure?—Made in a usual briquette machine—mechanical pressure, not hydraulic.

9646. You say that this coke dust is valuable in place of sand for making concrete. If it is valuable, why are there these big heaps of it left?—You know the kind of old-fashioned idea there is for sand; and, as Lord Palmerston said, "It is matter in the wrong place." As a matter of fact, these collieries are a long way from the point of consumption.

9647. They are wanting it themselves very often?—Yes; well, what is wanted is used.

9648. Your experience, I gather, is mainly with the Simon-Carvès plant?—Yes, but I know something of the others.

9649. Is the Semet-Solvay about as good?—I have carefully refrained from expressing any opinion either on coal washers or the various kinds of ovens, because I think we might argue that matter for a long time.

9650. It does produce a good coke?—The principle of all these ovens is the same; they differ only in construction—the mode of heating; and each, of course, claims that theirs is the best.

9651. But in reality, I suppose, they are all very much better than the old Beehive?—Well, the coke is not so pretty.

9652. You say that that is simply a matter of sentiment?—They have effected an enormous saving in the quantity of coke made per ton of coal.

9653. We have had some evidence given by a previous witness with regard to the desirability of having official statistics of the uses to which coal is put, so that people might know how much coal is used for railways, how much coal is used for ships, how much coal is used for domestic purposes, how much for metallurgical purposes, and so on. Do you think it is desirable that the Government should collect and publish statistics of that kind?—Statistics are always useful; but I do not know in what way that would help matters. I take it the main object of your Commission is to see how the use of coal could be economised for one thing, and to see if there are any coal seams—and there are doubtless many—which might be used if processes such as I have suggested were carried out in treating them.

9654. The point is this: supposing you could effect, for instance, considerable economy in gas making, or domestic uses, or steam raising, or in producing energy, is it not desirable to put your finger upon the spot where the economy can be most easily effected?—Yes; but I do not know that the statistics would give you that point. The statistics would tell you where coal was being used, but would not tell you where coal was being used wastefully.

9655. They would tell you where the disease, so to say, existed, and where the remedy was most necessary?—It would not necessarily be where the most coal was used, would it?

9656. No, not at all?—That is all the statistics would give you.

9657. (*Sir George Armytage.*) Do you see any objection to that?—Not the least; statistics are always useful in a way.

9658. (*Dr. Le Neve Foster.*) Could these statistics be given to some extent by the colliery owner?—Very largely. I do not know about shipping coal, but so far as the county of Durham goes it could be done; it is shipped as coking coal, steam coal, bunker coal, and the colliery owner knows exactly what purpose the coal is required for.

9659. Would the colliery owners have any objection to giving that information?—I do not think so; it would be no trouble to them at all.

9660. (*Mr. J. S. Dixon.*) You spoke of one objection to washing coal as being the mess that was made; but is it not a fact that many coal washers are worked with very little mess?—I was speaking of the old processes some 25 years ago. You will remember, no doubt.

9661. I thought you meant the practice nowadays?—I have been in coal washing establishments where they have been treating 3,000 to 4,000 tons a day, and there was no more dirt or dust in them than there is in this room—they were all closed and boxed in.

9662. It could be done without any objection in that way?—Yes. The refinements of coal washing have all come within, say, the last 12 years, and the discovery of feldspar as a medium of separating the shale from the coal has very much facilitated the automatic arrangement for that purpose.

9663. When you spoke of carbonising the tar you meant a less quantity of tar?—Yes, as compared with the gas retort.

9664. But it is useful as added to the coke?—Yes, added to the coke. In a gas works the common yield is 10 or 12 gallons per ton of coal in some cases; but in coke ovens it is not more than half that, the other goes into the coke.

9665. Have you any experience of utilising this coke breeze by forced draught?—Yes, I have been spending a good deal of money in trying to bring it about, but it did not succeed.

9666. Can you give us any idea of the cost per oven for the bye-product process?—It varies very much. It varies, say, from £400 per oven to £600 according to refinements.

9667. Is that with the recovery part as well?—I am including everything, the bye-product recovery part and the whole installation complete.

9668. (*Sir George Armytage.*) You say the whole oven. Are there 50 ovens in this plant?—They are built in batteries of 30 to 50. My estimate of £400 per oven, of course, includes all the appliances and plant and apparatus connected with it.

9669. And the building?—Yes, everything complete.

9670. Not washing?—Not washing; there is not very much washing done in Durham, the coal is fairly pure.

9671. (*Mr. J. S. Dixon.*) You spoke of a larger yield of iron when the blast furnaces were using retort coke.

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Do you attribute that to the coke or the higher pressure of the blast?—To that and the refractory character of this coke. It will bear a stronger blast. You can drive the furnace much faster really.

9672. We know a higher pressure of air will produce more iron?—Yes.

9673. Then probably it is more owing to that than the character of the coke?—The character of the coke enables you to use the higher blast. You could not use the higher blast without this very dense coke.

9674. You spoke about the loss of £350,000 per annum. Do you take into account the large price which is usually paid for Beehive coke as against retort coke?—No, I simply say we are making in Durham, say, 500,000 tons of coke less per annum than we might make from the same coal, and taking that at 14s. per ton, shows a loss of £350,000. The Beehive coke would be 15s.—that is, 1s. a ton more.

9675. That would require to be deducted from the loss if that difference were to continue in the future. You could sell your Beehive coke for 1s. more than this?—Well, there is a prejudice against this coke. I maintain this coke is as valuable as the other coke, but you cannot persuade the buyer to pay you quite as much money for it. My point is that if coke, instead of being produced in a Beehive oven, was made in a retort oven, you would get at least 10 per cent. higher yields, and therefore 10 per cent. more coke, which would be worth, say at 14s. per ton, £350,000.

9676. (*Sir George Armytage.*) That is assuming the values to be equal?—Yes.

9677. As a matter of fact, in the market you get 1s. more?—Yes, for Beehive coke.

9678. But you assume that the values are really equal, and your argument is simply on the fact of the modern oven giving you a yield of 10 to 15 per cent. more than the Beehive oven?—That is my point.

9679. (*Mr. Brace.*) Have you not allowed for that 1s. in your calculation?—Yes, I have; I am reckoning on a basis of 1s. per ton less than Beehive quality.

9680. (*Mr. Briggs.*) From the point of view of the colliery owners, if they had to sell all their coke at 1s. less on the other five million tons, they would not gain so much on it; but from the point of view of the public, if you believe that this new coke is as good as the old, then there is a gain of £350,000 according to your suggestion?—You are quite right; at present the market value of this coke is 1s. per ton less than Beehive coke, and it is only fair to take that into account. There would be, however, a gain in the counties of Durham and Northumberland alone, of £350,000 from the increased yield of coke from the coal, without reckoning bye-products. I make the national gain, if you reckon in the value of the bye-products, to be £2,900,000.

9681. (*Mr. J. S. Dixon.*) Would this £2,900,000 go to the pocket of the producer of the coke? There might be something less than that, because the quality would not be so good?—Well, that is the point; I maintain it is just as good. I have shown you, as a matter of fact, on Teeside, where a very large quantity of pig-iron is made, that one of the largest firms are using 5,000 tons a week for making two kinds of iron—a basic iron, which is said to require a very good fuel to produce, and a hematite iron; they are working alongside each other. First of all, while only using the same quantity of coke, they are getting a greater yield of iron per week than if they were using the Beehive coke. I think that is pretty conclusive as to its value. Some buyers are willing to pay a shilling more for their prejudice, that is my contention.

9682. (*Mr. Young.*) As to the £350,000 gain, would you not also have to add the 4s. 9d. per ton?—Admitting the minimum increase of yield by retort ovens at 10 per cent., that means 500,000 tons of coke, which I have valued at £350,000. Add to that the aggregate loss of bye-products, that is 3s. 3d. per ton of coke; you cannot again include the 10 per cent. more coke.—I have already done that.

9683. (*Mr. Briggs.*) Is it not possible that a coke may be made too dense? I have heard in the case of compressing coal in one case they got a worse price for their coke after they had compressed it, because it was found to be actually too dense, possibly too refractory?—Yes, but it is always overcome by a higher blast.

9684. It may be the case with certain customers, but not with others?—Yes; taking it for foundry purposes, I believe that a very, very dense coke would be the cheapest coke you could use for melting iron in a cupola, but you must have blast enough. *Colonel S. A. Sadler, M.P.* 28 Jan. 1903.

9685. This coke was probably used in a furnace of a much less high pressure than in the Cleveland district?—Yes.

9686. There it was considered to be detrimental.—Yes.

9687. The people told me they had to accept the less price?—Quite so.

9688. Did you take off the cost of recovery in giving these prices?—Yes. Take the sulphate of ammonia; I am reckoning that at 1d. per pound; that is £9 13s. 4d. a ton. To-day's price is £12 10s., so that I am taking off £3 for manufacture.

9689. That would be an abnormal price?—Well, it is abnormal; the last three years, I think, would average £11, and the difference between £9 13s. 4d. and £11 would be quite sufficient to cover the cost of manufacture, as you know.

9690. There is the point which Dr. Foster asked about the collection of statistics from the colliery owners. There would be no great difficulty, I think, in adding it to the annual return of the output?—I do not think there would be any difficulty.

9691. Provided they had for their guidance the proper classification, so that it was uniform?—Yes.

9692. They could not tell when coal is exported what it goes for, but they could group it as "export" or "bunkers"?—Yes.

9693. That might be done with the mines return?—Yes. Those figures would be generally reliable.

9694. And probably more reliable than if got from the users of coal?—Yes.

9695. (*Sir George Armytage.*) And where you did not know, it could be put under the head of "export"?—Yes; I do not know of any shipments being made where it is not specified what the coal is wanted for, because the colliery owner gives a different kind of coal for different purposes, so that they are almost sure to specify the purpose for which it is used.

9696. It may be for domestic purposes, or gas purposes when exported; you cannot always tell. Still, on the whole you think it would be easy and fairly accurate?—I quite think so.

9697. And it would enable anyone trying to deal with the question of economies to say how large a bulk of the trade a particular economy would affect?—Yes.

9698. If you knew you were using 80,000,000 tons for power purposes, you would know how far it was worth while to pursue the economy in the particular direction?—Yes.

9699. (*Mr. Sopwith.*) You said it is not generally known that the small and dust coal is much the purest part of the whole. What size would you mean by "small" in that case—up to nut size?—I mean the coal in Durham is often friable and crumbles down to a very fine dust indeed of itself. I allude to what I think is commonly known as "Duff" coal.

9700. On the other hand, your "Bands" are rather harder?—It is rather harder, and it does not crumble down. I have within my mind at the present moment a colliery where the large coal shows 12 per cent. of ash and the small coal only 4 per cent.

9701. That does not apply universally, although it may be so in Durham?—That is so.

9702. Is the mixing of the two seams for coking, the dry with the fat coal, carried out to any extent?—Yes. I am making 1,000 tons a day on those lines to-day—myself and the firms I am connected with.

9703. Have you any experience of dry coal having a great deal of moisture in it—I mean to say, natural water?—No.

9704. I think your Durham coals have not?—They are not wet. When I say dry, I mean bituminously dry.

9705. You have no experience of mixing a dry coal that has had, say, 10 per cent. of hygroscopic water?—No, it would be difficult to mix a mechanically wet coal.

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Colonel S. A. Sadler, M.P.

28 Jan. 1903.

9706. I mean containing natural water. There would not be any difficulty in mixing, would there?—As combined water does not show in the way of dampness in the coal, it would not affect the mixing. Attention is not sufficiently paid to the question of mixing and fineness. I have seen a coal that would not coke at all in the rough condition, but when ground into a very fine powder and damped it made a fairly good coke. I have seen coals mixed in this way and not producing good results, first of all for the want of perfect admixture, but generally it is from insufficient crushing.

9707. You are of opinion that the alternatives for making coke may be very much more extended than they are now?—Decidedly.

9708. (*Mr. Brace.*) Practically, from your experience, there would be hardly any class of coal that could not be coked?—That is so.

9709. If you crushed a dry coal, what is known now as an uncokable coal, could that be coked if you crushed it?—I think I mentioned a coal that would not coke in the Beehive oven. There are coals which if you put them into a Beehive oven and opened the door, the whole charge would run out like quicksilver on the bench, but those same coals if ground very fine and damped, make coke. I attach very great importance to the grinding very fine.

9710. That is one way of treating dry coal successfully for coking purposes, or you may, by proper admixture, as you say, use the dry coals in their raw condition with the fat coals and make a good coke?—Yes.

9711. You would not want to crush the dry coal if you mixed it with the fat coal?—Yes, in any case it must be crushed very fine, so as to get a mixture. The fatty coal in the process melts like pitch in the oven, and it takes up by contact the drier coal, licks it up, so to speak, or, as the collier calls it, mops it up—and forms one solid mass.

9712. In the operation of coking this mixture what effect has adding dry coals to a fatty bituminous coal upon the bye-product results?—You mean in the way of yields?

9713. Yes, in the way of yields, quality and quantity?—You see the yields with similar coals in the same kind of oven vary very much by the practice of the ovens, by the skill with which the ovens are manipulated, and by the care that there is no great vacuum on the ovens. One of the great troubles in connection with retort oven coking is that your men do not like to see gas burning round the doors of the oven. When this occurs they put the exhausters on to work more rapidly, and there is too much exhaustion on the oven, the air is drawn in, and that destroys the bye-products. The air going into the oven attacks the bye-products first, and enormously interferes with the yield; in fact, a leaky oven with an exhaust on it will give you no bye-products—the whole is destroyed—oxidised by the air.

9714. All things being equal, would the adding of dry coal to a fat coal have a tendency to reduce the bye-products?—I think it would. I think the dry coal would swallow up or would utilise some of the hydrocarbon of the fat coal.

9715. That seems to be natural?—I think it would.

9716. Would you recommend a kind of central establishment that would cover a certain area or a certain number of collieries rather than for each colliery to have its own plant for coking, bye-product, or briquette making?—I think there is something to be said in favour of your suggestion; but large collieries would make sufficient small coal to make it worth while doing it on the spot. If you come to add 1s. or 1s. 6d. carriage on coal, it is rather a serious matter. Then there is the handling of it. This small coal, as you know, in a well laid out colliery after being tipped on to the screens is never seen again until it is in the coke oven; it is not handled at all. By your proposal it would have to be lifted into trucks and taken out again. I think that handling and the carriage would be a very serious handicap

9717. Suppose there is a truck under the screen where the small coal is being screened off from the large, the truck may be as well taken 20 miles as one, or even 100 yards so far as the handling goes?—But you do not do that; you tip this coal on to a screen, and the small coal falls on to a belt and travels along to the crusher, and is lifted into the bunker on the oven. It is never touched.

9718. That is your system, but I know of some systems where the small coal, going to the truck, is sent by a separate operation altogether. In that case it would be no disadvantage to have central works which would include a certain area or a certain number of collieries?—Not at all.

9719. No matter whether the small coal be dry or fat, either by coking or briquettes, you think it could be utilised to advantage?—For coking?

9720. For coking or briquettes?—Yes, but I am afraid I do not quite follow you.

9721. I will tell you what is in my mind. In South Wales they gob a large percentage of the coal won. If all that coal were brought out instead of being gobbed as at present, from your experience do you think it could be all utilised to advantage either for the making of briquettes or for coking purposes?—I should think so; I am assuming that the coal is good coal.

9722. A dry coal—the small coal which is won in connection with the very highest class steam coal—And the ash would probably be about what, do you think? Do you remember what the ash is?

9723. I could not say.—It all depends upon the ash contained. Any coal that does not contain a very high percentage of ash can either be made into coke or briquettes. That is a proposition anyone will admit.

9724. Then the gobbing of such a large amount of that coal is, in your opinion, a national waste?—Yes. There is no such thing as that known in the north of England. There is not a particle of coal whether round, small, or whatever it may be, which is not utilised in some form or another in the north of England.

9725. Given the fact that this coal could be used for briquettes or for coking, if you were a member of this Commission would you recommend that that coal which is left in be now brought out?—I am very much surprised to hear it is left behind.

9726. It is the fact, nevertheless?—It is very astonishing; but not any serious quantity surely?

9727-28. Oh, yes. The gobs in many collieries are largely gobs of small coal, and not gobs of rubbish.—I should hardly believe that of enterprising South Wales. I suppose the explanation is that your market is for a large coal, and the large coal is so much more profitable than the small that it is cheaper to leave it than to haul it out.

9729. (*Professor Dixon.*) What royalties are now paid for any of these coking apparatuses like the Simon-Carvès?—There is no royalty on the ovens themselves. There is no patent at the present moment. All the patents have run out; but the erection of these ovens now is in the hands generally of those who originally patented them. For instance, the firm you speak of, Messrs. Simon-Carvès lay themselves out to contract for and erect the whole installation, including the residual plant, so do Otto Hilgenstock and Semet-Solvay; all these people take the work themselves and do it, and they have special expert experience and knowledge.

9730. (*Sir George Armytage.*) Do you work these ovens all day and all night?—Yes, and every day of the week.

9731. And draw them also?—They are drawn in three 8-hour shifts.

9732. And as regards the Beehive oven do you do the same?—We do not draw on Sundays, but we work the three 8-hour shifts with them.

9733. We had some evidence yesterday as to some ovens which were not drawn after a certain hour, and they had to remain during the night and to be drawn in the morning. Do you find there is any loss from that?—Yes, a very serious loss.

9734. It is more economical to draw them when ready?—The moment an oven is ready, if you do not draw it, you begin to lose carbon. No matter how close the doors are, air is drawn in and the carbon suffers.

9735. You were speaking of coke being made from mixed coal, the lighter and the heavier coal. Are they coals which have been drawn from the same colliery?—Yes, they are drawn from the same pit. I do know of one large coking concern in the county of Durham where

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they have an extremely dry coal, and they buy a sufficient quantity of a fatty coal, I think 20 per cent., to mix with it.

9736. And they find that profitable?—Yes. The coal they have in the Brockwell seam only just cokes, but they add 20 per cent. of Hutton coal (20 miles away) and then they are able to make a beautiful coke.

9737. On that question which you have mentioned as regards the quality of the Beehive coke and the other coke have you made any experiments upon them?—You mean the use of the two cokes?

9738. Yes, the use of the cokes in a blast furnace You say the market give you 1s. more for the Beehive coke than the other, but you apparently think they are of equal value?—I am sure they are.

9739. Have any test been made? Is there any proof of that?—Yes, many, extending over several years. I ought not to mention names, perhaps, but one of the largest iron smelting firms in Cleveland put furnaces alongside each other on to using these two kinds of coke (I know because I supplied the coke), and worked them together for five months, and it confirms the statement I have made in respect of the efficiency of one as compared with the other, because they found as regards the quantity of coke consumed per ton of iron produced that it was exactly the same, but in respect of the quantity of iron produced from the furnace, this retort coke gave a greater production. I may say they found they required 3lbs. more blast to get the best effects from it as against the Beehive coke.

Colonel S. A. Sadler, M.P. 28 Jan. 1903.

Mr. JOHN KNOWLES, called; and Examined.

9740. (*Sir George Armytage.*) Are you a mining engineer?—Yes, I am a Mining Engineer and General Manager of the Pearson and Knowles Coal and Iron Company, Vice-Chairman of the Ince Council, Member of the South Lancashire Coal Owners' Association, the Federated Institute of Mining Engineers, the Manchester Geological Society, and an ex-President of the National Association of Colliery Managers.

(1.) The collieries of which I am general manager are situated in Ince, Hindley, and Coppull, with an output of over 1,000,000 tons per annum, and employing between 3,000 and 4,000 hands.

I have had experience in working the whole of the mines in the Wigan district, cleansing of coal by washing, coking of coal, and utilising the gases arising from the process of making coke for generating steam in boilers.

I should like to point out that I cannot speak as an experienced coke-maker; my evidence, to be of use to you, will be given more on the lines where I think saving can be affected both in coke-making and in the utilisation of coal for briquettes

I have not had any practical experience of coke ovens with recovery of bye-products.

With reference to the manufacture of briquettes; my experience only extends to a general knowledge from inspections I have made and information I have had given me of the working of briquette plants which I have inspected, and from the erection of a briquette plant now in progress at the Pearson and Knowles Coal and Iron Company's Collieries.

(2.) Coal Washing.

The three processes of coal washing I know are:—

First.—The Luhrig Feldspar Washery. The slack is elevated to a revolving riddle and separated into three different sizes of coal, namely, nuts, pea nuts, and dant. The different sizes are separately washed in wash boxes, and the process of washing is carried out by the pulsation of water set up by wooden plungers, whereby the coal floats away with the water, and the dirt being the heavier body falls through a bed of feldspar 3in. to 4in. thick laid on netting at the bottom of the washer.

This process seems to wash the coal satisfactorily, and takes out of our slack from 5 to 12 per cent. of dirt, only leaving from 0·5 to 4 per cent. of loose dirt in the coal according to the class and quality of coal washed.

The nuts and pea nuts are sold, and realise an average increased net selling price of 6d. to 8d. per ton by washing process.

The cost of washing is from 3d. to 4d. per ton.

The fine dant, duff, or smudge passes from the wash boxes into two settling tanks, which drain the fine dant alternately. It is then taken out of the second settling tank and run into iron hoppers, in which it is conveyed to a range of 40 coke ovens.

Second.—Murton Washer.—The makers and patentees of this coal washer are Messrs. Wood-Burnett, Grange Iron Works, Durham.

The process of this washery is an improvement on the old trough washery, and cleans the coal by water flowing against trays working in an upward and opposite direction.

Mr. John Knowles. 28 Jan. 1903.

The coal, being the lighter body, is carried downwards by the water, and the dirt, being the heavier body, settles in the trays, and is carried upwards, and ultimately deposited in the dirt wagon. I consider this also a very good washer, and as a comparison I should think is quite as good as the Luhrig washery, and in my opinion will give similar results.

I may say I am not giving this opinion from experience. We had some difficulty in deciding which of the two we should adopt.

Third.—The only other washery I have had experience of is the old trough washer, and as this is now obsolete, I do not think it necessary to refer to it.

Although coal is improved commercially by washing, it must not be forgotten that the weight is diminished by taking the dirt out, there is therefore a loss on the yield over the quantity treated corresponding to the amount of loose dirt in the coal.

(3.) Coke Ovens.

I submit plans of coke ovens recently erected at the Pearson and Knowles Coal and Iron Company's Collieries.

These ovens are of the Beehive type, being built back to back, 20 on each side, with an elliptical flue down the centre.

9741. Have you built these recently?—They have been in operation about 18 months.

The size of the ovens is 11ft. diamenter, and the size of the elliptical flue is 9ft. high and 4ft. 6in. wide.

The fine dant, duff, or smudge referred to from the washery is brought by the hoppers over the top of the ovens, and they are charged from the top.

Five tons of dant is put into each oven for one charge, and realises on an average 60 per cent. of coke. If these ovens are kept in full operation all the week they would be drawn three times, realising 9 tons per oven per week—18,000 tons per annum for 40 ovens.

A slight reduction on the annual output would have to be taken from the total to allow for repairs.

The heated gases pass from the coke ovens along the elliptical flue, and are then utilised for generating steam by passing through three Lancashire boilers of 30ft. long by 8ft. diameter, with flues 3ft. 2in. diameter.

A side or bye-pass flue is provided with a damper to regulate the burning of the coke when required, and also for diverting the gases when boilers are off for cleaning purposes.

I estimate a saving of fuel by these three boilers, from calculations I have made of the water evaporated, at 1,800 tons per annum, equalling a saving value of £405 per annum.

In that case I have calculated the fuel for the boilers at 4s. 6d. per ton.

9742. You mean to say that fuel saved at 4s. 6d. per ton represents £405 for the year?—Yes, but the boilers are not quite kept in full operation, as sometimes we run short of coking slack.

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Mr. John Knowles.

28 Jan. 1903.

9743. Are these boilers used for drawing coal?—The boilers are used for a pair of hauling engines, and the whole of our workshop engines, they are also connected with the colliery boilers and the washing plant. They drive the washing plant and a dry elevator. The total cost of this coke oven plant of 40 ovens, with boilers, chimney, and loading arrangements, etc., came to £7,764.

Then as to the processes of making coke from coals usually considered non-coking, I am afraid I cannot give you much information upon that point beyond the process of making coke on the lines I have already described.

The washery I referred to deals with two or three qualities of coke-making coal, but the Beehive oven would not make marketable coke out of what I should define as non-coking coal, in the conditions under which we make it.

I believe there are other processes in which coke is made from coal which is usually considered non-coking.

The following section of the mines in the Wigan district, showing the coking and non-coking mines down to a depth of 730 yards, may possibly be useful to you:—

Mine.	Thickness.	Depth.	Quality.
	Ft. ins.	*Yards.*	
1. Riding Mine	2 6	66	Common steam coal.
2. 1st Ince Yard Mine	3 0	84	House coal, good quality.
3. 2nd Ince Yard Mine	3 0	94	Common steam coal.
4. Ince 4 Feet Mine	4 0	125	Good house coal.
5. Ince 7 Feet Mine	3 9	140	Very fair steam coal and house coal.
6. Ince Furnace Mine	3 9	161	Good furnace coal.
7. Pemberton 5 Feet Mine	4 0 to 4 6	241	Second class house coal and good furnace or steam coal.
8. Pemberton 2 Feet Mine	1 9 to 2 3	249	Good quality house coal.
9. Pemberton 4 Feet	4 0	268	Good quality house coal.
10. Wigan 5 Feet	3 10 to 4 0	400	Common steam coal.
11. Wigan 4 Feet	4 0	432	Good gas and fair coking coal.
12. Wigan 9 Feet	5 6	459	Good steam coal.
13. King Cannel	0 3 to 2 3	547	Very good Cannel gas coal and fair coking coal when washed.
13. King Coal	2 6 to 3 6		
14. Ravine Mine	5 6 to 7 6	583	Steam coal.
15. Arley or Haigh Yard Mine	2 7	618	Good gas, coking, and house coal, also good steam coal.
16. Bone Coal	0 18 to 2 0	668	Very good steam coal.
17. Smith Coal	1 9 to 3 0	691	Gas, house, and coking coal.
18. Arley Mine	3 0 to 4 6	730	Best house, gas, and coking coal.

This is the bottom mine of the Middle Coal series.

It will be seen that these mines lie at various depths from the surface down to 730 yards.

The coking coals I have referred to may be divided into two heads:—

(1) Good coking coals.
(2) Second quality coking coals.

In addition to this I should like to point out that there is in Lancashire a very large area of coking coal called the "Mountain Mines," lying below the Middle Coal series. These will undoubtedly be worked at a future date.

Two of the three Mines are, I believe, of good quality.

There is no doubt to my mind that in years to come appliances and developments will take place to work mines at a much greater depth than we do at present.

9744. What is the deepest you are working now?—The Arley, 730 yards deep, but I have been down mines in the Lancashire district 1,000 yards deep.

I also believe that some of the mines unworkable at present, and which contain a large amount of intercalated dirt, will, when the present better seams are becoming exhausted, be brought into the market, being made marketable by means of crushing and washing out dirt up to 30 or 40 per cent.

(4.) Briquette Making.

Although my experience (as previously pointed out) is limited to inspections and information I have gained in negotiating the erection of a briquette plant which is now almost completed at the collieries I am connected with, I believe the following information is reliable.

A briquette is any compressed block used for fuel or smelting. When used for fuel it is generally called patent fuel, and is known by that term in South Wales.

When the Government are purchasing briquettes there is a stipulation in the contract that they should not contain more than 8 per cent. of ash.

In my opinion there is a future for briquettes for the following reasons:—

The fine dant is converted into a block so that it can be used on similar lines to round coal either for house, furnace, or steam coal.

In my opinion another advantage in the future in making briquettes will be the utilisation of inferior slacks by the process of briquette making.

Another advantage is that you can stack briquettes for years without deterioration.

Briquettes can also be stacked in the hold of a vessel to give a heavier weight per cubic yard than ordinary coal, with absolutely no risk of spontaneous combustion.

The life of our coalfields will be to some extent increased if briquette plants are brought more into use, as at many collieries the fine fuel from the washeries can be caught into settling tanks, and the slack that is left down the pit at some collieries can be used up to a profit by converting it into briquettes.

The slack wherever it is left down the pit will never again be recovered.

The plants I have inspected in operation were made and the new one I am erecting is being made by Messrs. Yeadon, Son, and Company, Leeds.

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COST OF MAKING BRIQUETTES.

100 tons per day Plant.

	s.	d.		
Labour	–	4	per ton.	
Pitch	2	6	„	8 per cent.
Depreciation	–	2½	„	
Sundry cost such as locomotive dealing with traffic, &c.	–	6	„	
Steam and grease	–	2	„	
	3	8½		

200 tons per day Plant.

	s.	d.		
Labour	–	3	per ton.	
Pitch	2	6	„	8 per cent.
Depreciation	–	2	„	
Sundry cost such as locomotive dealing with traffic, &c.	–	6	„	
Steam and grease	–	2	„	
	3	7		

Estimated cost for 100 tons plant - £. 3,000
Estimated cost for 200 tons plant - 6,000

The fine slack for making briquettes would be supplied at 3s. 6d. per ton, and the selling price of the briquettes would be from 8s. to 13s. a ton. This shows a profit on briquette making of 1s. to 2s. 6d. per ton.

The commoner slack is not for house coal; it is the house coal where they realise 13s. a ton.

9745. (*Mr. Brace.*) And for steam purposes?—It is not from actual experience in selling the briquettes that I give evidence, but the information I have received is that they realise about 8s. a ton.

9746. That is made from the poorest small coal?—A commoner sort.

9747. (*Mr. Young.*) Sold at 3s. 6d.?—Yes. It must be pointed out that to make a briquette plant pay, a good deal depends upon the price you can realise in the market for the fine slack used, and the selling price realised when it is converted into briquettes. The price of pitch fluctuates to a great extent, which is an important factor in briquette making. I believe at the present time pitch runs up to about 45s. a ton, and the basis upon which I have estimated my cost has been a little bit below that.

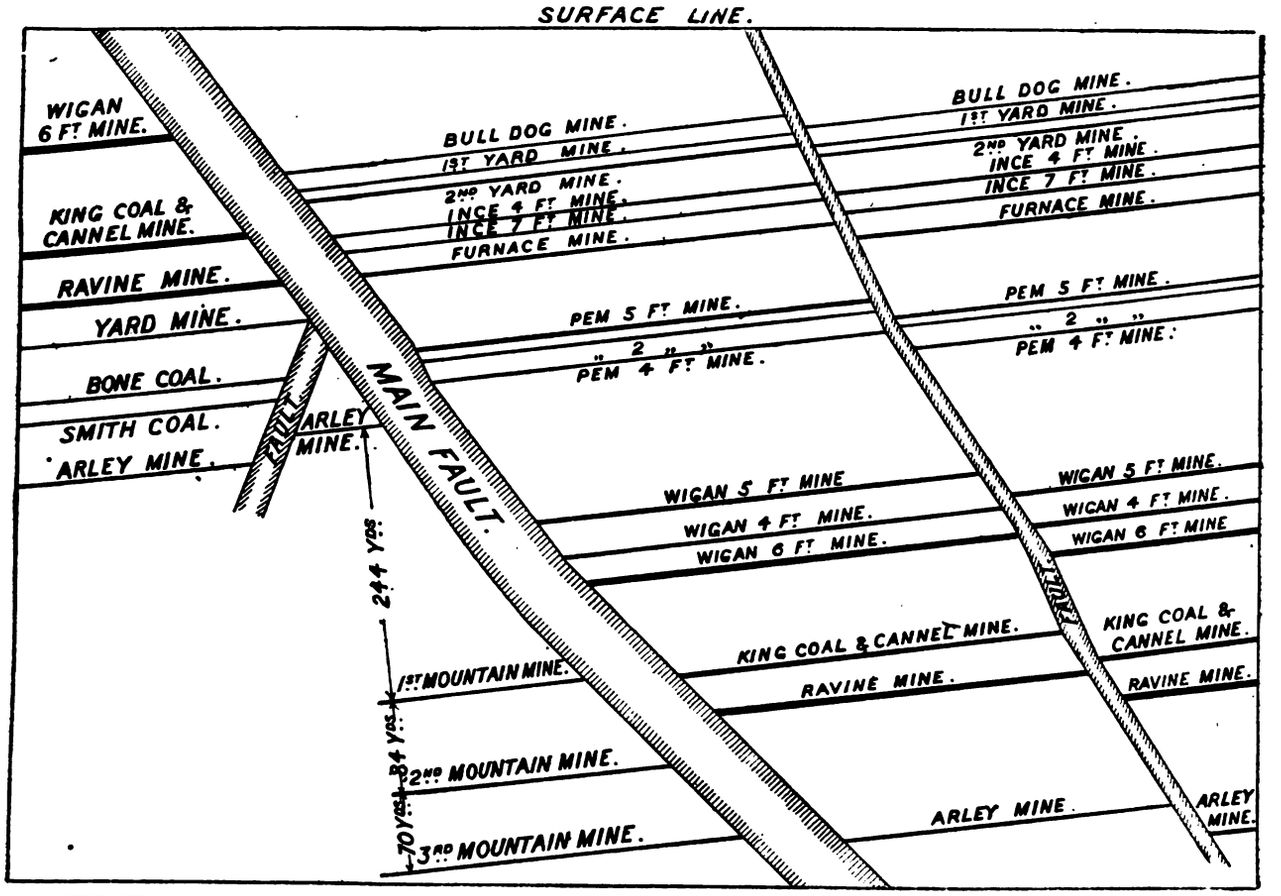
9748. It is over 50s. now?—Yes.

9749. (*Mr. Brace.*) Pitch is one of the bye-products from coke ovens?—Yes.

9750. And if you increase the bye-product arrangement you will therefore increase your quantity of pitch?—Yes, I refer to that a little later. This can be overcome by the colliery proprietor putting up his own carbonising plant, and making his own pitch, or by making bye-products at his coke ovens. Briquettes can also be made by other ingredients such as compressing and mixing the coal with lime and thick residue from oil, which is cheaper than pitch, but I have not seen this in operation.

9751. (*Sir George Armytage.*) Do you wish to add anything now?—I should like to add that I believe there are lots of mines in the Wigan district which at a later date will be utilised to lengthen the life of the coalfields. I have referred to the Mountain Mines, and I have brought here with me a tracing which shows that there is a very large area of the thin seams below, which can be worked, I believe, to a very fair profit. Associated with the lower Mountain Mines is the Gannister Bed, and they are being worked in a group, but I believe they have not been taken into consideration before in working out the life of our coalfields.

Section showing position of Mines in Old Arley and Moss Belts.



9752. You mean they were not taken into consideration by the last Commission?—I believe not.

9753. You are returning them this time?—Yes. The above section shows a very large area of Mountain Mines existing at about 600 yards, and another large area 1,200 yards deep.—(*The Witness explained the section to the Commission.*)—I quite agree that it would be a good idea to add to the information given on the deposit of plans of abandonment the reason of abandonment, and the amount of water, as near as can be estimated, that is being made and pumped at the time.

9754. In your opinion there are at the present time in the Wigan district considerable quantities of coal which have been left simply in consequence of the water?—Yes.

9755. (*Dr. Le Neve Foster.*) And that might possibly be dealt with by a central pumping station?—Yes, such station, however, not to apply to the whole of the

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Mr. John Knowles.

28 Jan. 1903.

collieries, only to the abandoned coal and mines which I have referred to.

9756. (*Professor Hull.*) You would work these Mountain Mines and the Gannister by driving across the fault from the existing collieries, not by sinking direct to them?—I had better explain; if you will notice, there is a 300 yards downthrow fault. The way in which I should work the coal on the east side of the fault would be to tunnel from the present Arley mine at 730 yards deep, and the way in which I should work the others below would be to sink the present shafts deeper. You have two belts of the Mountain Mines, the shallow depth and the greater depth.

9757. That would be 1,000 yards from the surface on the downcast side of the fault?—It is about 1,100 yards. I have another plan upon that. (*Witness explained the plan to the Commission.*)

9758. (*Dr. Le Neve Foster.*) You speak about a saving of £405 per annum by utilising the gases from the Beehive ovens. Would not the saving probably be greater if you put in bye-product recovery coke ovens?—I should think so. Do you mean the "saving" so far as the boilers are concerned?

9759. A general saving. You say you save £405 by simply utilising the burning gases to raise steam?—Yes.

9760. Would you not probably have made a greater saving if you had put in a bye-product recovery plant?—I should think so.

9761. I notice in your section that the coking coal comes in at a depth of about 432 yards?—That is so.

9762. The coking coals are the lower seams, and the non-coking coals are the upper seams?—Yes.

9763. You speak about the slack being left in the pits. How much is left in that manner?—We do not leave any slack in the pits in Lancashire.

9764. You speak about the slack being left down the pit at some collieries?—I refer more to South Wales and Staffordshire, and, I believe, in some portions of Derbyshire.

9765. That does not apply to Lancashire?—No, it was a general statement I made that any slack left down the pits now and not made saleable might be made saleable.

9766. (*Mr. J. S. Dixon.*) I understand the dant is washed in feldspar boxes?—Yes.

9767. Have you provided any flues in the Beehive ovens below the ovens?—No.

9768. (*Mr. Young.*) You said you thought it might be an advantage to mix the slack with the lime to make the briquettes?—Briquettes can also be made by other ingredients, such as compressing and mixing the coal with lime.

9769. In what direction do you think lime would be an advantage?—I understand from information I have received that in this way they can be made slightly cheaper.

9770. There are briquettes made with a mixture of lime?—That is what I am told.

9771. You do not know the proportions?—No.

9772. (*Mr. Brace.*) Had you known, when you were erecting your Beehive ovens 18 months ago, that you would be putting up a briquette-making plant, would you have put up a kind of oven that would have enabled you to have had a bye-product plant attached to it?—I think we should.

9773. You said something about South Wales. What is your experience of South Wales, and leaving coals in the mines?—My experience is this: I have been down one or two of the pits in South Wales, and I have also had it from general information, and read, that the slack is left down the pit. I make the statement because I take it this inquiry is looking forward to making the best use we can of our coalfields. I make the statement not with reference to any South Wales colliery alone, but anywhere where coal is lost. If it cannot be used as slack I think the day is coming when it will be used in briquettes to take the place of round coal.

9774. Do not name the collieries, but tell the Commission, from what you saw, was there much small coal left behind?—You see, I did not go down for that purpose, but I was told it was left down. I could not tell you about any percentage. I went to report on some collieries there, and I did not go into the question as to the coal left down the pit.

9775. Still, you have stated in your evidence that South Wales is one of the places where small coal is left behind, and I agree that you are right, in fact; and you further said that the time is coming when this small coal will be utilised either for coking or briquettes. I am rather inclined to agree with you there, but I want you to tell the Commission what you saw and what led you to that conclusion?—I am making a general statement; I am giving you my opinion that any coal wasted, left down the pit, is a loss to the country; and I think the time is coming when we shall all agree that if what I diagnose turns out to be true, a briquette plant in the future will be able to convert the slack into a briquette, and so increase your round coal output.

9776. In Lancashire you leave no small coal in whatsoever?—I would not say "whatsoever," but as little as possible. It is all filled in together and separated on the surface.

9777. You know, as a mining engineer, no reason why the same system should not be in operation in South Wales?—Except what I have been told, that there is no sale for the slack.

9778. You say that in your belief there will be a sale found for it either for coking, or for the making of briquettes?—Yes.

9779. There is no reason why the South Wales small coal should not be suitable for the making of briquettes, or equally as suitable as your Lancashire coal?—I do not know of any reason.

9780. Have you made an analysis of the two coals?—Of the South Wales coal, no.

9781. Look at your statement of the various seams: the house coal is 4ft. thick, and the Ince 7ft. mine you only put as 3ft. 9in. In what part of the coalfield does the Ince 7ft. come up to or approach the 7ft. to which reference is made?—I do not know how the name originated, but it is simply the name in the district.

9782. I suppose it must be near the outcrop?—I do not know of any in the Wigan district 7ft. thick; none of it exceeds 4ft. or 4ft. 3in.

9783. (*Sir George Armytage.*) When a seam gets a name it keeps it, I suppose?—Yes; you might take, for instance, the Pemberton 4ft. mine; it is in some districts called the Bickershaw 7ft. when it runs together with the Pemberton 2ft.

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SIXTEENTH DAY.

Thursday, 29th January 1903.

PRESENT:

Sir GEORGE ARMYTAGE (in the Chair).

Mr. BELL.
Mr. BRACE.
Mr. BRIGGS.
Professor DIXON.
Mr. J. S. DIXON.
Dr. LE NEVE FOSTER.
Professor HULL.
Mr. YOUNG.

The Secretary.
The Assistant Secretary.

Mr. JOHN HIGSON, called; and Examined.

9784. (*Chairman.*) You were good enough to send us a proof of the evidence which you intended to give, but were prevented by ill-health from giving on a previous occasion?—Yes. *Mr. John Higson.* 29 Jan. 1903.

SUMMARY OF EVIDENCE.

I am a Member of the Institution of Civil Engineers, Fellow of the Geological Society, and a member of the firm of J. and P. Higson, having offices at 18, Booth Street, Manchester. I have had an experience of about 40 years in the North Wales, South Wales, Lancashire, Yorkshire, Derbyshire, Nottingham, and Warwickshire Coalfields.

Waste in Working.

(1) I have been connected with mining in either one or other of the before-mentioned coalfields for about 40 years.

(2) I have dealt with bituminous coal, anthracite coal and semi-anthracite coal.

(3) The sections of the various coalfields are published and well-known. It is, therefore, unnecessary for me to deal with them. The deepest sinking I have made is that of the New Moss Colliery, about six miles east of Manchester, which is 951 yards deep. The sinking commenced from the surface to the upper coal measures; then the upper coal measures were passed through but were of thin section, and a fault intervened in the shaft, causing the sinking to miss the Great and Roger Mines, which have now been found by a tunnel at a depth of 510 yards from the surface. Below it, at a depth of 895 yards, the Three Sheds, or Great Mine, at a thickness of 6ft., was found, and at a depth of 951 yards the celebrated old Black Mine, at a thickness of 4ft. 6in., was found.

(4) It is quite impossible to describe what are ordinary circumstances, as the conditions under which seams of coal exist are so varied, but taking a mine with a good clean parting at the roof, and a good roof, and a good clean parting at the floor, and a good floor (that is, one that does not upheave), and assuming the mine to be homogeneous for the whole thickness of the seam (that is, where there is no interposition of dirt or carbonaceous matter, which is not coal), I estimate the loss in working as being very little, say 1 per cent. to 2 per cent. Where there is an interposition of dirt or carbonaceous matter, not coal, in the seam itself, even with a good roof and a good floor, the waste would in many instances be as high as 5 per cent. This is attributable to the interposition of dirt or carbonaceous matter falling in the working of the mine, and becoming mixed with the small coal of the seam, and so having to be thrown back in the goaf.

I know of other instances where the section of the seam is 7ft. 6in., and in the ordinary working of the mine, the top 18in. is thrown back into the goaf, because it is of inferior quality, and at the present time not saleable. In these cases I estimate the wastage would be from all causes about 25 per cent.

It is quite impossible to say what is the average wastage in working any particular coalfield, as the mines differ in every district, and to arrive at an accurate figure, one would require a section of each mine, so as to compute theoretically the number of tons of coal that exist in the seam, and it would also be necessary to have the actual number of tons of coal sent out from each seam, and the computation of all these details would make it a very intricate matter.

My experience of wastage is from 1 per cent. to 25 per cent. in the ordinary working of the mine.

(5) In the event of gob fires which destroy coal, or pillars of coal which have to be left as a protection against water, although frequently I have to deal with these difficulties, I have not the details at hand to say what the effect has been upon any particular seam being worked, nor yet what its relationship would be to the general average of the district. A large quantity of coal is lost through fire and water, and as a protection against these two dangers.

(6) My experience is, that the most profitable seams are worked first, without regard to the effect upon other seams which may be injured thereby, but in those mines which are worked care is taken so to work that the one does not interfere with the other.

(7) I could give a great many particulars of seams which are worked in advance of each other, but a few, probably, will suffice.

On the east side of Manchester there exist two valuable seams of coal, called the Great and Roger Mines, with an intervening section of about 30 yards between them. The effect of working the lower, or Roger Mine, first is to remove the pressure temporarily from the upper, or Great Mine, and so to set the coal, and make it very difficult and hard to get. If, however, sufficient time elapses between the working of the lower or, Roger, and the working of the upper, or, Great Mine, to allow the strata to again descend and press upon the upper mine, the effect would be to

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Mr. John Higson.

29 Jan. 1903.

crush the upper mine, and make it practically all small coal. The proper method of dealing with these mines is to work the upper seam first.

In the St. Helens district of Lancashire there exist the two Florida Mines, with a few feet of intervening strata. Here it becomes absolutely necessary to work the mines nearly on the same breast, having a drawing road in the bottom mine.

In the Wigan district there exist the Wigan Four and Nine Feet Mines, with about 30 yards of strata intervening. Here it is advisable to work the upper mine first, and afterwards to work out the lower mine.

In South Yorkshire there exist the Parkgate, Thorncliffe, and Silkstone coals, with an intervening strata between the Parkgate and Thorncliffe Seams of about 30 yards, and between the Thorncliffe and Silkstone Seams of about 70 yards.

The proper way to work these seams would be to work the upper mines first, but, as a matter of fact, I have always known the lower, or Silkstone Mine, to be worked first, because it is most valuable. The effect of the working of the Silkstone Seam on the Thorncliffe and Parkgate Seams is to set them, but, again, after a period of time has elapsed, when the strata has descended, and the pressure of the strata has again rested on the upper mine, they become more friable and easier to work, but make a less quantity of round coal.

I am of opinion that if the upper mines were worked first they would be wrought to better results as regards round coal and with less difficulty in maintaining road ways.

(8) In some cases it is better to work the lower mine first, but, as a rule, it is more economical to work the upper seam first, so as to get the largest quantity of round coal, which realises the greatest value per ton.

(9) Some leases specifically define that the mines leased shall be exhausted in their order of geological position, but, as a rule, the working clause in leases in the coalfields I have named merely stipulates that the mine shall be worked to the greatest advantage, and according to the best and most approved method of mining in the district, and in some instances the words of this clause are strengthened by the phrase: "To the greatest advantage of the lessor and lessee." I have known very few instances of lessors interfering with the working of the mines, provided the lessees do not cut off by carelessness, ignorance, or through any other cause, areas of coal which, in the opinion of the lessor, ought to be worked. It is reasonable to suppose that the lessee would work the mines to the greatest advantage as regards the quantity of round coal he would produce, and so, as a working rule, the lessor does not interfere with these matters. The lessor's surveyor, however, would, and does frequently claim to be paid for coal which the lessee may have left behind through carelessness or otherwise.

(10) I have known cases where lessors have compelled lessees to work out the whole of their estate before dealing with any other estate, which had the effect of causing waste, from the fact that foreign coal has been interlocked with the main area leased. This does not often occur, but I have known isolated cases.

Coal is frequently lost by reason of small lessors having an exaggerated idea of their mineral property, and refusing to lease, and so getting at cross purposes with the mine worker, who refuses to have his hand forced, and so sometimes he leaves small areas of coal behind.

(11) I suggest that in colliery areas which are in operation under large leases, and which frequently have to deal with small intervening properties, the colliery proprietors or the major lessor should have the power to compel such minor lessors, so interlocked, to lease their mines at a fair royalty value; in case of difference the same could be referred to the arbitration of properly appointed authorities, who would be competent to deal with these questions.

(12) I am of opinion that the system of working coal mines, known as "long-wall," is that which ensures the least waste in the removal of the coal. Some mines, however, can be worked to the greatest advantage by "pillar and stall," but, as a rule, "long-wall" is that system of work which produces the nearest approach to the theoretical yield from any seam.

(13 and 14) In dealing with pillar and stall work, where pillars are small, and where they have to stand for a considerable period of time, a natural creep, or downward pressure of the strata, takes place, which causes the coal to become crushed. In these cases pillars are sometimes very difficult to remove, and a greater waste ensues, owing to the roof and floor having been interfered with by the weight, and so becoming mixed with the small coal of the mine which is thrown back into the goaf. Here the waste would be serious; probably 5 per cent. In mines of this description the long-wall system of working, or a modification thereof, would be that which would ensure the seam being worked to the greatest advantage to realise the highest percentage of round coal, and, consequently, the least wastage.

Deterioration of coal seams by exposure to atmosphere is not very great, and is merely superficial. A few inches of coal removed from the face would make the seam assume its natural character as to appearance, etc.

(15) In some mines, which have been worked pillar and stall, but which have been turned to long-wall working, I have realised an excess of as much as 5 per cent. to 6 per cent. of round coal, and even more. Some mines are so constituted that the difference of large and small coal in long-wall working and pillar and stall working is not very marked. I have some mines under my guidance where the long-wall system could not be adopted. These mines are shallow, and the remark would apply in a great measure to shallow mines. I think the system of long-wall working is an evil created to overcome a greater evil; that is, where you cannot maintain the roadways in the coal at a reasonable cost to work back and exhaust pillars, then the long-wall system of working is cheaper, but where the pillars of coal stand without crushing, then pillar and stall is quite as economical as the long-wall system, but these conditions do not often happen; therefore, as a general rule, I say the long-wall system of work is that which produces the best results in every respect.

(16) If pillars of coal are to be left they should always be of such a size that when they have to be worked back they can be split up by straight-work or narrow-work into smaller pillars, and removed as rapidly as possible; therefore, the larger the pillar in the first instance, within reason, the better.

(17) I have known mines where 25 per cent. of small coal was thrown into the gob, owing to its being of inferior quality. There are several seams of this description in South Yorkshire. I am working one where the miners are not allowed to send out the bottom portion of the coal. If they did it would interfere with the other coal, and seriously damage its selling value.

(18) There is much loss by reason of undermining or holing being wastefully made in good coal. Wherever there is a holing dirt it ought to be used for holing purposes, and the coal left solid. Most colliery proprietors and mining engineers are wide enough awake to understand this, and the practice is very general, especially in the Midland Counties, and, indeed, everywhere now where there is what can be called a good holing or floor dirt.

(19). There ought to be no ribs or pillars for the support of shafts. Coal ought to be either left solid or no support at all left. At great depth, and in many seams of which I have had experience, I think shaft pillars are of little or no use, and a source of great expense. A pillar ought to be left of such proportion that the break-over at the surface would be remote from the shaft. It is impossible to have any rule which is accurate in all cases as to the area. Such area would vary with the dip of the seam and the strata generally, and the depth of the shaft and seam from the surface.

(20) When coal has to be left unworked for the support of buildings on the surface, there is a fixed rule for regulating the size of the pillar according to the depth and inclination of the mine. It is always wise, beyond a point where the break theoretically would occur at the surface, to have a zone of safety of at least 20 per cent. of the depth from the surface. To show the enormous quantity of coal being left in pillars for surface support, I may say that the coal bought to support 4 miles of the Manchester, Bolton, and Bury Canal alone, amounted to 8,950,998 tons.

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(21) There are several places, in my experience, where coal has been left which might have been worked, not only without occasioning damage to any serious extent, but so that the mine could have been worked to a profit.

(22) From my experience, it is very seldom that mines of coal which have been abandoned could be re-opened without considerable addition of cost.

(23) Barriers of coal are very seldom, if, indeed, ever, left along boundaries of any particular colliery leasehold or area, but in nearly all cases it is wise that barriers should be left between one colliery and another.

(24) The waste and loss occasioned by these barriers left could in some cases be avoided by some arrangement whereby the water in the coalfield could be dealt with at some particular point, but it would be sometimes difficult to do this, because the water would not always gravitate to any one or two points. There might be required a number of pumping stations, and so bring about practically the same thing as now exists where each colliery leasehold or proprietor is supposed to take care of himself as against his neighbours. I am of opinion that in many cases this could not be materially altered to advantage, although I am obliged to admit that in some instances a central pumping station would work well.

(25) Barriers of coal are left to prevent influx of water from old workings. In some instances the old workings are drained off; in other instances the water in old workings is so great in quantity, and the feeder after the accumulation had been pumped out would be so great, that a colliery proprietor would not be able successfully to deal with it, and so he leaves a barrier of coal against water, and works what coal he has dry.

(26) The percentage of coal used for fuel at an average colliery is about 5 per cent. In some cases it gets up to 10 per cent.

(27) Coal-cutting machinery is rapidly coming into operation in the various coalfields with which I am connected. Personally. I am of opinion that the coal-getting of the future will be by coal-cutting machinery, and I may emphasise the fact that I have spent very large sums of money in installing plant and working coal by machinery, and such working under my supervision has been very successful.

(28) I know of many instances where mineral owners as distinguished from colliery proprietors have been unwilling to grant leases except on their own terms, and in some cases have refused any terms. I have also known cases where facilities for drawing coal from foreign properties through leasehold areas of the colliery have been refused. It is a common thing for a lesssor upon whose property the shafts are sunk to exact a wayleave for foreign coal varying from ½d. to 3d. per ton, and sometimes more.

(29) Coal has, no doubt, been lost by there being no accurate plans or records kept to show the extent of the workings.

(30) No. It would not be possible to reduce the amount of coal left in pillars by stowing or packing rubbish.

(31) I think that much small coal which is now left underground by reason of its containing so much dirt and shale will in future, by washing, become saleable to a profit, but where the slack itself is of inferior quality, containing very little heat, it is doubtful, unless it were washed and mixed with petroleum and made into briquettes for steam purposes, that it will ever be used.

(32) I cannot suggest a remedy for much of the avoidable waste, beyond the following:—

In some instances the miner is inexpert or careless, and allows, in the holing in the dirt under the seam, coal to fall and become mixed with the dirt, and so render it of very little value. Some lessening of the waste would undoubtedly be effected by a close supervision of the miners, if such a thing were possible.

In some instances barrier coal, as herein foreshadowed, between a group of collieries might be avoided by the colliery proprietors agreeing to deal with the water at one central pumping station; but some barriers, I think, would in every case be advisable to prevent influx of foul air from one colliery to another, and to confine, in the event of explosion, the damage to the smallest area, that is to the particular colliery in which it occurs. It might be argued that if two collieries worked to the boundary line and removed coal, after a time the goaf or the place from which such coal was removed would become consolidated, and be as effectual as a barrier of coal. In some mines this would be so; in other mines hundreds of yards of goaf would remain and would always allow the passage of foul air from the workings of one colliery to another. It is impossible to fix a hard-and-fast law.

Barriers would be quite unnecessary in some mines under proper arrangements agreed to by colliery proprietors, whilst in other mines it might be advisable to leave small barriers merely to protect one colliery from another.

The Limit of Depth of Mining.

(33) In sinking the New Moss Shaft, which is about 951 yards deep, the increase of temperature was 1° for every 82ft., or, in other words, when the temperature was 49° Fahr. at the surface, the temperature of the strata at the bottom of the pit was 84° Fahr.

(34) I have worked coal at a depth of 1,056 yards from the surface, and I have also worked coal at 1,020 yards from the surface. I am now working two seams at 700 yards from the surface, and at 730 yards deep a seam 4ft. thick; in fact, most of the mines I am individually connected with are seams at great depths from the surface.

(35) The seam I worked at 1,056 yards deep was 4ft. 6in. in thickness, and at 1,020 yards deep 6ft. in thickness; I am now working at about 700 yards deep two seams 4ft. 6in. thick, and at 730 yards deep a seam 4ft. thick.

(36) The temperature of the air in these seams varies at distances from the shaft. The temperature of the return air at 1,056 yards deep was about 87° Fahr.

I had a series of careful experiments made at the Dukinfield Collieries about the year 1892, with the result that the temperature of the return air and of the strata was about 84° Fahr. at a depth of 1,000 yards from the surface, and taking the temperature at the surface at 49° Fahr., the increase of temperature was practically 1° for every 86ft.; but there must have been some increase of temperature in the return due to other causes than the strata, as the temperatures taken in the strata realised a temperature of 74° Fahr. at 1,987ft., the temperature at the surface being taken at 49° Fahr., or an increase in temperature of 1° for every 79·5ft.

At a Wigan colliery the Arley Mine is being worked about 730 yards from the surface. I made some experiments, and found the temperature at the surface was about 61° Fahr. At 1,450 yards from the shaft the temperature of the air had increased to about 81° Fahr., and the highest temperature obtained at the working face was about 90° Fahr. The temperature of the return between the shaft and the working face was 86° Fahr., and at the point where it returned into the upcast shaft 72° Fahr. The average temperature of the return was, as aforesaid, 86° Fahr., and the difference in temperature when the return air entered the upcast would be due to the leakage of fresh air through the doors.

Assuming 86° Fahr. to be the average temperature of the return air, and also the temperature of the strata, there was a difference between the temperature at the surface viz. 61° Fahr. and the temperature of the mine, and, as I assume, of the strata, of 25° Fahr. In this case the increase of temperature is 1° in every 87ft.

(37) My experience is that men do not work at the coal face more than six and a half hours per day. Trammers or hurriers and ropelads work from nine to ten hours, varying in different coalfields.

(38) The tonnage produced per man varies with the thickness and hardness of the seam. Assuming 4ft. to be the average thickness of a mine, under normal conditions, about three tons per day would be the quantity of coal that each individual collier would send out.

(39) No means whatever beyond watering the roadways have been adopted to reduce the temperature of a mine. I am of opinion that the future will produce some development which will enable mines to be worked at a much greater depth than 4,000ft.

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Mr. John Higson.

29 Jan. 1903.

(40) At greater depths the coal is almost universally worked on the long-wall system.

(41) The difficulties of sinking upwards of 4,000ft. do not increase with the depth beyond the mere winding of the débris, which is not a very great item. The difficulties of sinking are generally very near the surface, and consist of quicksands and water. The cost of a plant to raise produce from a depth of 1,000 yards as compared with, say, 300 or 400 yards would be practically double, the cost of maintenance greater, and the cost of raising fuel to the surface probably 2d. per ton more.

(42) Greater depth means greater crush of the coal. Assuming strata to weigh 35cwts. per cubic yard, the weight of 1ft. deep, 1in. square, would be 1lb., as there are 144in. in a square foot. Therefore, as an instance, at 100ft. deep there would be 100lb. pressure per square inch, and at 4,000ft. 4,000lb. pressure per square inch, or 1·8 tons per square inch.

(43) The effect of the crush due to depth is a larger proportion of small coal. An instance may be given of the same seam of coal worked at 200 yards deep giving 55 per cent. of best coal, and at 550 yards giving about 20 per cent. of best coal; but this proportion would vary with the nature of the seam itself.

(44) The cost of getting coal must increase with the depth of the mine from the surface, but such cost varies very much with the nature of the seam and the roof and the floor. I have known shallow mines cost more to work than deep mines, even taking into consideration the greater depth of winding, etc., and consequently the more expensive plant. It is almost impossible to assume the same conditions in mines at great depths as in those at shallow depths. At shallow depths the crush of the strata is light, but generally the mines have more water and frequently bad roofs. I have known mines of great depth worked upon the long-wall system, with good roofs, and consequently comparatively light cost; or, in other words, the greater the depth the more adaptable the mine is to the system of long-wall working. Thus it might cost less to work the same mine at a greater depth than possibly it would at a shallow depth, where the long-wall system is not adaptable, but the larger proportion of round coal would, in my opinion, be got from the shallow mine.

(45) The crush or grind of a mine would be considerably more at great depths than at shallow depths. Any seam liable to spontaneous combustion owing to its containing pyritous matter would have a greater tendency to ignite at greater depths than lesser depths. As a matter of fact, my experience at great depths of spontaneous combustion is nil, but the nature of the mine has not lent itself to such a condition of things, whereas in the Derbyshire and Warwickshire coalfields at comparatively shallow depths gob fires are a very common occurrence; but here it is the nature of the mine itself and the surrounding strata that brings about spontaneous combustion.

(46) I think the commercial value of deep seams is as great as that of shallow seams. The coal improves in quality, as a rule, at greater depths—I do not mean produces more round coal, but the quality of the coal itself is generally better, especially if it be bituminous coal, and even the deep steam coals I have proved, though of less thickness, are of better quality than where the same seams have been found at shallow depths.

The cost of production is greater owing to more expensive and heavier plant required. The hauling arrangements are more expensive, the winding is more costly. The working of the mine is generally, but not always, more costly at great depths than shallow depths.

The selling price of deep bituminous seams has, in my experience, been higher than in shallow and commoner seams.

I cannot say what will be the result of working at great depths those seams which have hitherto been worked at shallow depths. Probably the cost and selling price will present the same difference as is now existent.

9785. I think there are one or two questions which we should like to ask with regard to that statement?—Yes.

9786. Referring to the first column under the heading of "Waste in Working," you say, "My experience of wastage is from 1 per cent. to 25 per cent. in the ordinary working of the mine"?—Yes.

9787. Can you enlarge upon that. There is a large margin between 1 per cent. and 25 per cent.?—I think possibly I could explain it better in this way: in the ordinary working of a coal seam, which is clear between the roof and the floor, and where the roof is a good roof and the floor a good floor, the waste, as a rule, does not exceed 2 per cent., save where wastage occurs through the leaving of barriers as protection against other leaseholds, or as a protection against water, or for other mining reasons which arise from time to time. It is impossible for me to give you a percentage of what that wastage is. I pointed out to you that in one instance the protection of a canal in Lancashire required 8,950,998 tons, and I suppose we may more than double that before the canal is absolutely protected. Then again, in almost every colliery with which I have been connected I have found it necessary to leave barriers of coal against out-crop water—against old workings which have been made in many instances more than 100 years ago. That is especially the case where we are working what are called shallow mines, such as we find in the neighbourhood of Leeds in West Yorkshire.

9788. I take it that 25 per cent. refers to extreme cases where very big barriers are left, and where extraordinary things occur, such as having to protect railways, canals, and so forth. You include that, do you not?—No, I do not mean that. I know of mines without any respect to outside surroundings, where every superficial yard of the mine has a wastage of 25 per cent., and I will give you instances.

9789. Of course, it is very important to obtain this information, because we have to make some deduction from the theoretical area?—Yes. In working a mine like what is called a Wigan 9ft. mine——

9790. You cannot get closer than that?—No; that mine would be 7ft. 6in. thick. Barely 6ft. of the seam is sent out of the shaft.

9791. Then, going further on in your statement, upon the question of limit of depth of mining, you say, "No means whatever beyond watering the roadways have been adopted to reduce the temperature of a mine. I am of opinion that the future will produce some development which will enable mines to be worked at a much greater depth than 4,000ft." Can you enlarge upon that at all, and tell us your reasons for saying that?—It has never been done, and therefore I suppose some people might say I was travelling far beyond record. But it seems to me to be perfectly feasible to put into the intake air-ways of the mine cooling or condensing apparatus close to the working face, which would reduce the temperature of the air current, so that at the working faces it would be comparatively cool, and of course it would expand and become heated after it had passed through the working faces. But the temperature of a mine in the return air-road, which is not used for hauling purposes, would be a matter of indifference: it would not affect the situation of the worker, because the men are not allowed to pass through that. Of course, to suppose that such a thing would happen, there would have to be a slightly varied arrangement of the intake air-ways as compared with those which exist at the present time. The main intake air-ways are very often the main intake hauling roads where the coal is brought to the main inclines, engine planes, and so on, so as to bring the coal to the shaft. But if the scheme I am suggesting were carried out it would mean that there should be a separate intake air-road where this cooling apparatus could be placed nearer to the coal face.

9792. Then have you any notion as to at what greater depth we should be able to work in the future?—I do not think 4,000ft. will be the limit. I have worked 3,400 or 3,500ft., and the difficulties of the roof were in that particular instance not nearly so great as they were in a mine which was only 1,560ft. from the surface.

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9793. (*Mr. J. S. Dixon.*) In the same seam?—No. I was going to say that the nature of the roof and of the floor have a very great deal to do with the difficulties of working mines; and strange to say, although the weight at very great depths is very heavy, or, rather, I should say, the downward crush is very heavy—at 4,000ft. I pointed out to you that there would be 1·8 tons upon the square inch, of downward pressure—this pressure very often, with a strong roof, only increases gradually, and by building packs the descent of the strata is a gradual one, and is not arrested until the roof of the mine has met the floor of the mine. When the original roof has met the floor of the mine, then taking perhaps 3 or 4 feet of solid strata out of the roof of the mine would give you a roadway which would last perhaps for 20 years. That is where you have a good roof as distinguished from a rotten roof; and my experience is that you get better roofs due to the compression of the strata at the great depths than you do at the shallower depths.

9794. (*Mr. Brace.*) Would you rip up into the roof and then put your rails upon the fall after a certain amount has been cleared, to make your height, or would you wait until the bottom has met the top?—When we take a level which is merely a level separated by packs, perhaps 12 feet wide on each side, where there is no solid coal about it—because you cannot work these deep mines in what we call pillar and stall, but they must be worked in one continuous progress (long-wall)—we take out the coal, and supposing it is 4ft., if that were a main roadway it would want at least 3ft. ripping out of the roof as we go on. Then there is a gradual and constant downward crush of the mine, and that goes on until the height becomes so low that we are obliged to take another rip: probably that might be 18in., or 2ft., just depending upon circumstances, to give you height. After that the mine begins to gradually steady itself; we do not have the same rapid fall or downward pressure; the pressure, no doubt, is the same; but it is better resisted by the construction of the roadway, and when the roof of the mine has met the floor, then, with one more rip, that is, one more of 2ft., or 3ft., or 4ft., whatever you may require, then that roadway so constructed would, with a good roof and in such mines as I have been working at 3,400ft. or 3,500ft. deep, last probably for all time.

9795. After you have ripped up in that way do you not find a kind of natural rock top which is very much stronger than the first roof or any intermediary roof you may meet with?—It all depends; sometimes the rock is right on the coal, and sometimes we have strong Linsty, or what they call in the North of England post girdles; it is a shale in transition; but the rock, if I may use the term, is very silicious; and that makes a capital roof for ripping, and gives all the requirements we want in a mine, and is perhaps the best roof we can get. If we come to a rock that rock generally forms the top, but if that top should be so near to the coal that it would not provide for the necessary height, then we should have to rip in the rock, and that is an expensive thing.

9796. You have to take it as you find it, I suppose?—Yes; it might be in that sense cheaper and better to get the height out of the floor by taking up the floor, but when you do that you sometimes disturb the packs that you have on each side, and therefore when you can rip out of the roof (expense being taken into consideration), it is a better thing to do so.

9797. But you could not have anything like a permanent roadway which would stand well if you took to cutting the bottom as against ripping the top?—I should prefer the top.

9798. Splitting a bottom would always disturb your gobs?—Yes.

9799. You would protect yourself, therefore, by saying that for a really permanent cheap roadway the roof and not the bottom would be the best?—Yes, in 99 cases out of 100. I have to be careful, because I know that where the bottom is sufficiently hard, by leaving a ledge of about 1ft. from where the edge of the pack was, we have taken out of the bottom, perhaps from 15 to 16 years ago, and it is standing to-day.

9800. (*Dr. Le Neve Foster.*) You spoke about the 9ft. seam at Wigan, and you said there was 25 per cent. waste?—Yes.

9801. What causes that waste?—The coal is very inferior, and the colliery proprietor would find a very great difficulty in selling it; therefore it is thrown back into the goaf. It is recognised as between the lessor and the lessee that for that 18in. no royalty would be paid, and in very many instances it is left in the mine entirely. Now where the top in this mine becomes better, as it does in some isolated cases, it is sent out, and then the waste is not so great.

Mr. John Higson.

29 Jan. 1903.

9802. Why is this coal poor coal—is it in regard to the quantity of ash?—Yes.

9803. What percentage of ash is there?—I was going to say that when the creation of the coalfield took place it was a muddy, viscous mass, and there is no doubt that more or less silica and matters of that kind and impurities flowed over the lagoon where it was being formed and settled in the mud, and so made a class of coal which is not sufficiently good to sell at the present day.

9804. What percentage of ash would it contain?—I have never tested it, but this particular seam, I should think, would contain upwards of 25 per cent. ash.

9805. Can you remove that by washing?—No, because you see it is held in physical combination in the masses of the coal itself, and washing would not remove it. If you ground it to dust and washed it, probably you could wash it out. In order to answer your question still further, because it is an important one, this peculiarity does not exist except in this particular mine. I am working mines in Yorkshire, between Barnsley and Sheffield, which are in the cream of the Silkstone coalfield, and there we have a seam of coal which is called the Park Gate coal. There the bottom portion of the seam is filled with ashy matter. I have not analysed it, but it is not carbon, and it will not burn, as the collier says. The bottom of this 4ft. seam (1ft., or 2ft. 2in., or sometimes more) is a quality of coal into which the miner puts his pick to hole, to bring down the other 3ft. by excavation; and according to the rules of this particular mine, this bottom coal ought to be thrown back into the goaf. Now we did there try to wash the small coal. It all came up in a very fine coal; sometimes it would almost slip through your fingers—it was bituminous. We tried to wash it, but we could not wash out the ashy impurities. Of course, we wanted to wash it for coke-making purposes. I think I may say that to-day, where we wash the very best qualities of coal, we have from 6 to 8 per cent. of ash still left in the coke, which, of course, must have been in the coal; and where we do not wash, if you take South Yorkshire all through, I think if I said from 11 to 15 per cent. that would be a very fair average of the ash in South Yorkshire coke. As it takes 33 cwt. of that class of coal unwashed to make a ton of coke, you can readily see what the proportion of ash would be in the coal.

9806. With regard to this coal which has 25 per cent. of ash, would it burn?—Yes.

9807. Could you use it now on the spot for creating power?—It is done, but you meet with this difficulty, which is a practical one: supposing you knew at the first that you had this 25 per cent. of rubbishy coal, you might so arrange your boilers and have blowers, so that you could use this coal; but where, say, boilers have already been put down, it is not practicable with the existing boiler plant to burn this foul coal, because steam pressure is lost, and the man cannot get the steam up, you lose out-turn of produce, and the fact that you are burning a few more tons of expensive coal is a mere nothing in consideration of the extravagant cost which would be placed upon the works by not raising the quantity of coal that ought to be raised.

9808. If you had suitable grates you could use it?—Yes. There are several blowers used; there is the Wilton furnace, which is a furnace using very small inferior coal, of which I have placed thousands of tons upon the muck-heap because I could not sell it at any price. Now we are burning that inferior coal by using what is called a Wilton furnace, or forced draught. We bring the coal by a trail chain out of the "dant" heap, and we bring it in front of the boilers, and there are little pipes with valves which admit this dant into the combustion chamber of the boiler; and then this Wilton blower, which is a steam blower, blows the furnace up and it burns this inferior coal. The effect is that through the bars we make small bricks—I do not mean that they are really bricks, but we are burning the alumina into a small clinker. The fire-bars are in motion, and

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Mr. John Higson.

29 Jan. 1903.

they are continually disturbing the fire, and so the clinker falls into the cleaning chamber beneath the fire-bars, and there is no necessity for the man to open his boiler door, but he simply puts his cleaner into the chamber under the bars and brings out the clinker.

9809. Then, as a matter of fact, this inferior dust can be utilised by suitable boilers—By suitable draughts—forced draughts—I think it could. I think you could burn almost anything.

9810. Then, as a matter of fact, a certain amount of valuable material is being thrown into the gob and lost?—I think so.

9811. In this particular seam it is to the extent of 25 per cent. of coal?—You can easily see why. If the colliery proprietor sent that coal up, the lessor, or his agent, who are generally very intelligent individuals, would immediately put a royalty upon it.

9812. (*Mr. Brace.*) Did I not understand you to say that there is some arrangement by which you do not pay royalty upon that inferior coal?—Yes.

9813. So that if you brought it out it would be free of royalty?—I do not think so. The understanding is that it is so bad that it has to be left in the mine. If the lessor's agent, when coming round upon his half-yearly survey, saw that considerable quantities of this coal were being sent out for fuel purposes, he would say, "You must pay some royalty for it, because you use it."

9814. Then it is a question of royalty, and not a question of value?—The royalty that the lessee would have to pay would be such that it would be a better thing for a colliery proprietor to burn a better class of coal. Although I say this, I have no doubt that in many collieries that coal is sent up to some extent without any royalty being paid. It is not altogether thrown away.

9815. (*Mr. Bell.*) You pay the royalty by the foot?—Yes, by the foot thick per statute acre.

9816. (*Dr. Le Neve Foster.*) It is, as Mr. Brace says, more a question of royalty than a question of inferiority?—Yes, and at the moment there is a direct development in the utilisation of bad coal.

9817. (*Mr. J. S. Dixon.*) With regard to this matter of the 25 per cent. loss, I understand that is an exceptional state of things?—It varies. I can take you to where there is 10 per cent. or 8 per cent.

9818. Take the district with which you are acquainted generally: what would you call a usual loss in working?—It depends on the seam. There are several seams in South Yorkshire where you must put 25 per cent. as the loss. I will tell you why: you have all heard of the Barnsley thick coal; it consists of the bags, day-beds, the top softs, the hard coal, and the bottom softs. There are very few collieries in which the day-bed is worked; it all tumbles back into the goaf; they cannot get it, and they do not reckon to pay for it, and that is very often 2ft. thick out of 8ft.

9819. (*Sir George Armytage.*) But could you give us a more general answer; have you taken out, for instance, a series of mines and made a whole average of the lot by which you could give anything closer than from 1 to 25 per cent.? Many of our witnesses have calculated out collieries with which they are acquainted; they have taken the percentages of all, and thrown them into one average?—Well, they cannot do it; they may have made an attempt to do so, but it is impossible. I should think from my experience that about 5 to 6 per cent. would be a fair average of the wastage in mines.

9820. (*Mr. J. S. Dixon.*) That is what I wanted?—Yes, but at the same time you will kindly take it from me that that is not a mathematical calculation.

9821. With regard to this cooling arrangement, which you anticipate may be adopted for great depths, can you give us any idea of what you consider the limit of mining, because that is really the information we want to obtain if such a thing is adopted. Would you say 5,000ft. or 6,000ft.?—I do not see that 5,000ft. would be an estoppel.

9822. From your experience, you would state to the Commission that you think 5,000ft. is probably not an insuperable depth?—No, I do not think it is.

9823. (*Mr. Young.*) With regard to the inferior coal seams which you speak of, containing about 25 per cent. of ash, what do you think might be the cost of crushing and washing that coal?—It would not exceed 4d. per ton

9824. Then that coal should be profitable to work in an ordinary state of trade, should it not?—Yes. Now I will qualify that. I pointed out to you in my report that people were now considering the advisability of making briquettes; I do not mean briquettes for house purposes alone, but briquettes for ocean-going steamers. Several of my clients are moving very largely in that direction, and they have patents whereby they can diffuse into the briquette, as it is being made, petroleum, which makes the briquette, as they say—of course, the thing is in its infancy—as good a steam-producing thing as the best steam coal. Of course, they travel now in the direction of consolidating oil—oil furnaces.

9825. You say you do not pay any royalty upon this inferior coal when it is thrown back?—No.

9826. You would have, in all probability, to pay a royalty upon it if it was known that it was sent away?—I think so.

9827. Inasmuch as there would be increased cost incurred by crushing it and washing it to make it useful, do you not think it likely that you would be able to have a reduced royalty upon that to meet that increased cost?—I should say that would be the natural trend of events. Of course, a prudent colliery proprietor would say now to his lessor, "If I make this top coal merchantable, which hitherto has been considered of no value, instead of paying you 5d. per ton for this mine, will you let me have the top coal at 2d.?" and then the fight would come in as to how much top coal he ought to have credited to him.

9828. Is there much of that inferior coal? What area might it cover?—There is a great deal in the Wigan coal-field still.

9829. With regard to the crush that you spoke of, I should like to ask you whether you work on the pillar and stall method.—Every method.

9830. Long-wall as well?—I work on almost every method—pillar and stall, modified pillar and stall, long-wall and modified long-wall.

9831. At that great depth?—At that great depth absolutely long-wall. Supposing it were possible to drive 20 yards of roadway in one shift, and the workmen left at 2 o'clock, at 10 o'clock that night it would very likely all be in; the roof cuts rapidly, and comes down.

9832. Have you formed any opinion as to whether there will be any advantage in driving right to the boundary in opening out a mine of that description at great depth, and bringing it back by long-wall?—Well, that is the policy I pursued at a colliery which was working about 1,000 yards deep. We drove roadways about 60 to 80 yards wide—that is, a long-wall face, with two roadways, intake and return; we were obliged to have them that width in order to get sufficient fall of strata to enable the pack to maintain the roadway. We drove that, I think, 1,000 yards. Then we worked back in long-wall patches, practically working backwards long-wall. I think in some mines that is the best.

9833. Do you not think it might be the best method in all mines at great depth?—No, I think every mine varies, like every human constitution.

9834. (*Mr. Briggs.*) I suppose one may take it for granted that coal-owners do not leave those inferior coals in the pit if it would pay them to bring it out?—No, I do not leave them in if I can bring them out to a profit.

9835. You, as a coal-owner's adviser, would not permit it, would you?—No.

9836. Is it not the fact that, at least in West Yorkshire, most of the royalties are paid by the acre, irrespective of what is brought up?—Yes.

9837. Therefore, in West Yorkshire, at least, the bulk of the coal-owners would have that coal for nothing, if there were such inferior coal?—Yes.

9838. Take the case of the Stanley seam in West Yorkshire; I daresay you know the seam?—Very well.

9839. And you know that a good deal of the upper part of that is left in?—I frequently have to buy it for the Lancashire and Yorkshire Railway Company, and I do not pay for that rubbishy coal at the top.

9840. That is not an avoidable waste which we could expect would be much altered, is it?—Questions were put to me upon that point, and I said that the tendency to-day was to put up machinery in the shape of

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boilers and blowers, or, if you like, increased draughts and chimney power, to burn an inferior quality of stuff. Take a certain colliery; the holing is absolute muck; but by putting in those forced draughts we can burn it. Now, I am not able to state to you to-day whether the interest on the increased outlay which we have incurred in doing this, and the repairs to delicate machinery, make it a paying game or not. All I say to the Commission to-day is, that we can burn that stuff, and I said that people were turning their attention to burning inferior coals where they would not pay an increased royalty.

9841. Then, if they had to pay an increased royalty, I presume I may take it that the remedy would be a higher price of coal—I mean, that is the one thing which would certainly avoid any waste, is it not?—Yes, no doubt.

9842. And that, as long as good coal is relatively cheap and a coal-owner is unable to dispose of all his good small, he has not much incentive to take up what has been considered rubbish and what is thrown away at the present time?—There is no incentive.

9843. Have you not found in your experience that there has been great difficulty with miners in making any terms for filling that if they have been in the habit of throwing it away?—Yes and no; there are difficulties and difficulties overcome; but it is always a difficulty to get a miner to do anything he has not been accustomed to.

9844. I have in my mind a case where a proportion of a seam holed in like that was thrown away entirely, and in order to send it out the men demanded the full tonnage price which is paid on the very best coal, thus rendering the cost about three times the value of the stuff on the surface?—Yes.

9845. Of course it continues to be thrown away?—Yes.

9846. That is a much more serious matter than the question of royalty, is it not?—Yes.

9847. It amounts to perhaps three or four times the royalty?—Well, it is much more serious; that is quite sufficient. I myself have tried to get the men to fill this inferior coal by offering them 3d. a box.

9848. That is to say, absolute shale?—Yes, absolute shale or rubbish.

9849. (*Mr. Young.*) What size tub do you refer to?—In that particular mine which I am thinking of they held about 6 cwt.

9850. Was their objection partly that it would not pay because they could fill other coal for which they were better paid?—Quite so.

9851. Could not that even then be got over by sending in what is termed "night met"—shifters—to fill that sort of coal?—No, because that stuff has got to be filled away or chucked into the goaf before the other coal has dropped—in this particular case. If you left it on the floor the result would be 20 per cent. more of ash in your coke, because this small dirty coal will get into the slack which is coked.

9852. (*Mr. Brace.*) Still, there is something to be said from the men's point of view, that if this cheap coal is to take the place on the tram of coal which would bring them in three or four times the amount, that would be a dead loss to them?—That is quite true.

9853. (*Mr. Briggs.*) That is a matter of arrangement. If the men have to shift it, in any case they already occupy time presumably in doing that which is supposed to be included in their payment for the other coal. If they were to lose the getting of better paying coal to get less paying coal their complaint would be perhaps legitimate?—I do not think the miner is entitled to much consideration in that respect. As a matter of fact what he does is to fill the dirty coal into the higher priced coal.

9854. (*Mr. Brace.*) You may say that, but you have your protection against that; the law of the land protects you, and the Mines Act protects you?—Well, I have been in mines for 40 years, and I have never been able to prevent a greater or less amount of this bad stuff being put with the coal.

9855. (*Mr. Briggs.*) I know that you have had a wide experience, and I wish to know whether you corroborate me, that there is an enormous increase in the amount of dirt sent up in the last eight or ten years in a given mine? That is my first question, and my second question is this: that the mines which are being worked to some extent now are dirtier mines *per se* than they were a little while ago?—Yes, the cream has been taken off.

9856. There are two reasons for it; one is that the mines are more difficult to clean, and the other is that the discipline of the mine is so much more lax than it was?—Yes.

9857. And that has led to much greater waste on the surface in the tonnage of coal which we appear to have drawn. We have paid for dirt instead of coal in many instances. Is that your experience?—Yes. Whenever wages are high and trade is good, or rather whenever trade is good and the employer can sell his coal at a large profit, everyone is immediately in touch with that. The manager is lax in his management, and it always has been, and always will be the case, that in good times you will have dirtier coal sent up. Mind you, the customer takes it without a grumble; but let the trade go down, and let there be a great fall in price and a slackness in demand, then, although your coal is very much better, there is much more grumbling about it.

9858. (*Sir George Armytage.*) Everyone is more careful, naturally?—Yes, everyone is more careful.

9859. (*Professor Hull.*) Do I understand you that in suggesting that for the purpose of cooling the face at very great depths, such as 4,000 or 5,000ft., there should be a special charge of cold air artificially cooled sent down to the face, that that would require a third shaft?—No.

9860. You have an upcast and downcast shaft at present?—Yes.

9861. You do not think it would require a third shaft?—Certainly not. What I am thinking of is this. Supposing you are laying out a new colliery, and you lay out a main intake and a main return, of course it is cheaper to keep one road or two roads than it is to keep three, and you would only lay out two at the present time, and make them bigger and spend money on them. Supposing you were to follow out the scheme which I am thinking of, you would have to drive, to make an efficient job, a third road, which would be the intake air road. When you get within 100 yards from the face, we will say, you might have a chamber 40, or 30, or 20 yards wide—whatever you found you could maintain in that particular mine—and supposing you had a lot of columns—thin pipes—filled with some freezing mixture in such a way that they would not burst your pipes (you would have to arrange for that, which can be done), and then passed the air through and round those pipes, and brought it round again to the faces just at the place where the miner is working, he would have cool air. The point you would have to consider would be how far an arrangement like that would impede and obstruct the general air current. It might be that you would have to mix this cooled air with some of the normal temperature air, and it might be that you would have to let some of the air go away down the main road, and never approach that particular line of face, so as not to bring about a congestion in the air road. I do not think there would be any difficulty in doing it, but it has never been tried, because it has never been necessary. As a matter of fact, at Dukinfield when we were about 1,100 yards from the surface, the man who was asthmatic could breathe very much better underground at our mines than he could breathe on the surface, because of the compression of the air, and the flame of the lamp elongated an inch—you would have to make all sorts of arrangements for that sort of things in your lamp carriage.

9862. Is there any objection to your answering questions about the Dukinfield Colliery. I believe it stopped working, did it not?—Yes.

9863. Is there any objection to your informing us what was the cause of its stopping working?—I cannot answer you, because I do not know. I may tell you this: that I offered to lease the mines personally, but my offer was not considered a favourable one. There is a great deal of coal there.

9864. I suppose in stating your opinion that it might be possible to work down to, say, 5,000ft. from the surface, you would only consider that seams of good quality and thickness could be worked at such a depth as that?—In that question I suppose you are imagining that the coal trade would be at its present fixed point.

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Mr. John Higson.

29 Jan. 1903.

9865. No, I am not. I think that the price of coal will be very much higher than it is at present?—I am one of those who think that in future mines that cannot be worked to-day will be just as profitable as those which are being worked to-day. I am working mines to-day which 25 years ago I should have laughed at.

9866. As regards quality?—Well, as regards quality it is not so good as other mines I am working, and the thickness is only about 2ft. I believe you must look for very great help in the working of mines to coal-cutting machinery. The difficulty is that, as distinguished from America, where the employer gets the bulk of the profit resultant from putting coal-cutting machines in a mine, the miner takes practically the same price for getting down the coal after it has been holed by the coal-cutting machines as if he had holed the coal by hand.

9867. (*Mr. Briggs.*) It is so in Yorkshire?—Yes, and it is so to a great extent in Wigan.

9868. (*Professor Hull.*) He does not appreciate the greater ease of getting down the coal by coal-cutting machines instead of by hand?—He has not to do the holing.

9869. Might we not say with regard to this question of depth, and necessarily increased cost of working, and with regard to all those points about outlay of capital and length of time in getting the coal from the face up to the shaft, that those matters will practically adjust themselves in the end by the question of profit and loss on the working of the coal in any particular mine?—Eventually that would be so. That is to say, as long as the comparatively shallow and cheap worked mines are *en evidence*, the man who tries to work the deep and expensive mines would no doubt be at a disadvantage.

9870. But the shallow and good mines are being very rapidly worked out in Lancashire, are they not?—Yes.

9871. (*Mr. Bell.*) A great deal of coal is left underground by barriers being left?—Yes.

9872. That is to say, barriers being left as between the boundaries of property and also by internal barriers?—Yes.

9873. I wish to ask your opinion as to whether any coal is left behind in the shape of barriers in consequence of what I may call the prejudices or particular fancies of landlords, which is unnecessary for the keeping of the coal, over any particularly large area, and which, by being left behind in those barriers, is lost?—The answer to that is almost "Yes" and "No." I do not think the lessor is to blame for specifying that barriers should be left to protect his property. Where he knows there are large accumulations of water or old colliery workings, and where the area is well known by the lessor's agent, he does specify for those barriers to be left there. You are touching upon a question which has often occurred to me. If there could be a coalition of lessors, barriers which are left now in many cases might be done away with, and three or four collieries might agree to leave a surrounding barrier against any danger, but no barriers of any magnitude, except to provide against the ventilation of one colliery going into another, which might be 10 or 15 yards. I think that great widths of barriers might be avoided by a coalfield being carefully considered in the first instance; but when you take a coalfield such as we have here, which has been worked for so many years, and which is all intermined like rabbit warrens, if I may use the term, it would no doubt be a very difficult matter to have what you might call a general system of barriers.

9874. (*Sir George Armytage.*) You mean a larger coalfield—several colliery proprietors' holdings put together?—Yes.

9875. (*Mr. Bell.*) Apart from the difficulty you mention, and recognising the desirability of some coalition or general understanding, would you consider that it would be a wise thing for this Commission to suggest that some arrangement of a public character should be made by which joint proprietors should be bound to agree to the prevention of this large waste by consenting to barriers between their properties not being left?—I do not think it would be of any material service. As between colliery and colliery, if there is no water danger, a man leaves not an ounce more of coal than he is obliged to in the shape of barrier—that is, as between one proprietor and another. Where there are water dangers attacking one colliery and not the other, the man who is first attacked is obliged to leave a barrier against the existing evil, and the man who is not attacked calculates the length of the life of the colliery that is first attacked, and if he thinks it is a longer life than his he does not leave any barrier.

9876. But I should rather like to go a step beyond that, and suggest to you that there are barriers left between properties where those considerations cannot arise, and they are left for no other reason than to form a boundary between properties?—I have never known it.

9877. I will suggest to you an instance?—I do not say it is not so, but I cannot remember one.

9878. Then perhaps I need not go into it if you do not remember?—I have known cases where lessors have compelled colliery proprietors to leave so many scores of yards against the outcrop, where the outcrop went into water-bearing strata. I have a case to-day where we are not allowed to work within a less boundary than 100 yards from the surface, and I am morally convinced that I have got nearly all the water that I should have if I were right up to the outcrop. So that that would certainly be a part of what you are suggesting. But who is to determine that beforehand? Supposing I had worked that out and more water had come, I should be at the mercy of the lessor or his agent. The lessor's agent wants to keep his own reputation; he says, "It looks probable that the lessee would work to the surface and drown out the colliery, so I will protect it."

9879. As a matter of fact, going back to the past within your recollection have barriers been really effective for the objects with which they were left?—I have never left a barrier where the water has broken through.

9880. You have never left a barrier which has been tampered with?—Well, I cannot say that—I could not get to the other side of the barrier—but I have never had a barrier where the water has come through, and I have had as much as 280lbs. of pressure.

9881. (*Professor Dixon.*) I should like to ask one or two questions upon your evidence with regard to the temperatures you have observed. Were those temperatures in New Moss Shaft taken by yourself?—They were taken under my direction, or some of them were.

9882. You give the instance at Wigan Colliery of the Arley Mine, which you state is being worked about 730 yards from the surface?—Yes.

9883. There you give the surface temperature as 61°—Yes.

9884. Was that the temperature of the air at the moment?—Yes.

9885. Not the average temperature?—It was the temperature before they went down to make the experiment.

9886. In all the evidence you have given with regard to temperatures, do you always take the temperature of the air at the moment, and not the average temperature of the surface?—We have always done this: first of all we take the temperature at the surface, then it is a work of some time, as you know, to take the other temperatures; if by the time of taking the last temperature the temperature at the surface had gone up 10°, my evidence would be wrong by 10°.

9887. Then you have not attempted to take the average temperature of the surface as regulating the temperature of the mine below?—No; these temperatures were merely taken at the time, not for the purposes of this inquiry, but to satisfy my own mind, and at the moment I took the temperature at the surface my assistants went down in some cases and took the temperature in the mine, because, of course, it is a long distance to get from one point to the other, as you understand.

9888. I quite understand; but you have given the increase of the temperature with the depth?—Yes.

9889. 1° for every 82ft. in the first case?—Yes, that is what it worked out to.

9890. And in each case that happened to be in the temperature of the air at the surface for the time being?—That is correct.

9891. You know that that is not the usual method employed for obtaining the increase of temperature?—No, but I think it is a very fair one, because in all these matters unless you can telephone from one place to

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another, and make sure that you have every man at his post making the experiment at the moment, there will always be some amount of leakage.

9892. Does the temperature of a deep mine vary very largely in summer and winter?—Not beyond certain distances.

9893. Exactly. Then surely it would be wrong to take the temperature at the surface at 61°; that must have been taken in the summer, and if you had taken it in the winter it might have been 31°?—Yes.

9894. You would have had an enormous difference in the rate of increase of temperature, according to whether you had taken your observations in the summer or the winter?—In the shaft, if you keep out of strata, it is not as great as you would think. Of course it is colder in winter at the bottom of the shaft.

9895. But at the working face in a deep mine it is exactly the same temperature, is it not?—It is.

9896. Have you ever known any difference in deep mining?—No, I could not say so; I could not say that when I got to the face I could tell you whether it was summer or winter.

9897. That is the universal experience of everyone?—Yes, I should think so.

9898. Therefore it would not be right to take the surface temperature at just what it happened to be on a summer's day or a winter's day; you ought to take the average temperature?—It would be more correct.

9899. Because in one case you take 49° as the surface temperature and the other 61°, and you argue from those two figures as to what the increase is?—Yes.

9900. Then a little further on in your statement you assume 86° Fahr. to be the average temperature of the return air, and also the temperature of the strata?—Yes.

9901. Why do you assume that to be the temperature of the strata?—I am speaking now from my local knowledge of the face. At that point I was of opinion that the temperature of the return air had acquired from the surrounding strata the necessary increment or decrease, whichever it might be, because it would be give and take—so that it was practically the temperature of the strata.

9902. The strata in that particular return road?—Yes. We find this, that at the far end, where the amount of air current is naturally very much less, and where there are many horses, men and lights, the temperature sometimes rises to 90° in these deep mines; but when we get back on to the return air current we find it gradually losing temperature, and there is a decrease of heat until it gets to a point where it seems to be normal, until it comes to that point again where it becomes mixed with leakage from the doorways, and then, of course, the air gets cooler again. I should say there is a point in every mine where the temperature of the air current is practically the temperature of the strata. That is what I mean to convey.

9903. And if you want to get the temperature of the strata, then you would take the average temperature of the return air as being correct?—Possibly.

9904. You would not make a hole into the freshly-cut coal and put a thermometer in to get the temperature of the strata?—No, because I should have to find out whether I had got to the point where I had the normal temperature in an air current, and I might make a mistake.

9905. But supposing you made a 6ft. hole in the freshly-cut face of coal, and put the thermometer in, and left it there for 12 hours, would not that give you the temperature of the strata?—You have done that, I suppose?—Yes, many times.

9906. What is the highest temperature you have obtained in that way at Dukinfield or elsewhere?—I think the highest I ever got was 83° or 84° at the Ashton Moss mine.

9907. In the coal itself?—In the mine itself. It was so hot that if you sat with your ordinary pit garments on you immediately began to perspire on the place where you sat; that is, if you were in the working face that was cut, off the main air current, say, in the top end of a goaf at the last place, if you sat down on the strata you could feel that it was warm.

9908. You say only 84°?—Only 84°. I never got any register higher than that.

9909. You know that very high temperatures are reached at Pendleton?—Yes, so Mr. Bramall states. I have been with the late Thomas Baker Forster in that very mine where he took experiments, and in which I think I myself took 94° in the working face. There was no air in it at all. But the temperature of a working face is dependent upon something more than the depth. I have a mine which at 500 yards is as warm in the air and warmer than it was at 1,000 yards deep at Dukinfield, because there is pyritous matter, and it is always being oxydised, and there is a certain amount of heat generated, which finds its way into the air, and we get a higher temperature therein, that is to say, in the air, than that which is due to the depth of the mine from the surface.

9910. To what do you attribute the increase of temperature which can be got by reason of men nd horses being present and working, and so on, in your opinion? I understand you to say you found the temperature of the air in the working face higher than the actual temperature of the strata?—Yes; I should think you might get 8° or 9°.

9911. That is to say, higher than the temperature of the strata?—Yes.

9912. Is that your experience?—Yes.

9913. Is that the result of actual experiment?—No, it is not. I am afraid we have too many things to think about in coal mining to make experiments of that sort. If you want those taken I shall be glad to take them for you; but I have not done so.

9914. (*Mr. Young.*) You stated that you think it would be possible to cool the air by a certain method. Would it be costly to make such an experiment as you have in your mind?—Not in some mines, but it might be in others. It might be that the third road suggested already exists, and then it would not be costly.

9915. Do you think such an experiment could not be made without a third road?—Supposing there are only two roads, and the main intake is a haulage road, usually at the far end of the hauling machinery there is a pair of ventilating doors; you cannot put the doors on the haulage machinery, because they would be in the way. Now, supposing I took the air, on the suggested plan, up to those doors, and then cut down-hill or up-hill—down-hill probably would be better—for the intake for that road, which is really the way in which it is done now, and I put my suggested cooler in that road on the intake side of the main intake door; then there is the main intake cut down, and then you drive along the level or incline you do that really in mining—then put the cooler *there*, and let the air go into the face, and then into the return air road in the ordinary way.

9916. What approximately might be the cost of a single experiment do you think?—I do not think it would exceed £1,000.

9917. (*Sir George Armytage.*) Now, will you kindly take your new proof. We have finished with that which was prepared previously. Compare the pit-head and screening arrangements in use 25 years ago and now?—The pit-head and screening arrangements 25 years ago were of a very simple character. The screens for the most part were only making round coal and slack; sometimes nuts. At the present day the pithead and screening arrangements on the pit hills are wonderful examples of engineering. I know of collieries where on the same pit head there are at least eight varieties of coal being screened. The motive power for the screens is either steam or electricity. Travelling belts are arranged to bring the slack from the various screens up to a large metal box, which stores a large quantity, so that from time to time the wagons can be loaded under and the smudge box emptied. This arrangement avoids having an extra wagon road for the smudge. Where there are eight varieties of produce, the wagon-ways to the screens are expensive, and extend over a large area.

9918. Then will you describe the arrangements now adopted within your district?—The most recent arrangements that I know of, and which commend themselves to my mind, are those which I advised for a colliery in the Lancashire district. The produce is raised in the ordinary pit boxes from a depth of about 450 yards to a pit hill about 23 feet above the rail level, supported by iron columns and cross girders. From the pit mouth the box runs a certain distance along the pit hill, with a gentle incline to a point where it is caught hold of by trail chains, which lift it to a higher elevation, from

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Mr. John Higson.

29 Jan. 1903.

whence it is tipped by a circular tip. The coal falls on to a perforated screen, which makes best coal and cobbles. The former proceeds from the mouth of the screens along a picking belt about 70 feet in length, and thence direct to the round coal wagons. A cross belt at right angles takes the cobbles on a similar and parallel belt to the cobbles wagon which has a separate road. The slack, screened from the foregoing, is taken on to a shaker at right angles to the two picking belts last mentioned. The residuum of this—that is, when the nuts have been taken out—is lifted and screened at a higher elevation into small nuts, pea nuts and dust, all of which, with the exception of the dust, have their own particular wagonway.

9919. (*Professor Hull.*) What is the difference between cobbles and nuts?—The cobbles are intermediate between best coal, round coal, and nuts; they are about the size of your hand.

9920. (*Sir George Armytage.*) How many sizes is the produce of the mine divided into by the screens?—Six and eight.

9921. What are the percentages of these sizes to the whole?—It is impossible to give the percentages of the various sizes unless the percentage of every colliery is given, because they all vary according to the friability and mechanical construction of the coal, but at the colliery I have in mind, that is the one I gave you in the first instance, the percentage of dust is about 19 per cent. Then I call your attention to a colliery in Yorkshire where practically the same method of dealing with the coal is adopted, and where the percentage of dust is between 33 per cent. and 35 per cent.

9922. (*Mr. J. S. Dixon.*) What are the sizes of the perforations that that passes through?—The dust would go through about a $\frac{5}{8}$ in. screen in the case I give you of 35 per cent. Of course, we make nuts, pea nuts, gas cobbles, round coal, steam coal, and steam nuts. In dealing with the coal in the manner I have described at the particular colliery of which I have given you details of the screening arrangements, the higher prices which are obtained for all varieties of screened coal, compared with what they would have realised if sold as round coal and slack, practically leaves the dust—that is, the 19 per cent.—to the colliery company without any cost. Taking this as being worth 2s. per ton, or from that to 2s. 6d. per ton, and assuming that 19 per cent. of dust is realised as the result of the screening, and that it could be sold at, say, 2s. 6d. per ton, it would mean an increased general average selling price of about 5¾d. per ton, because it is clear that whatever you get that is not smudge goes to increase your average selling price. I think I may fairly say that the best screening arrangements, although they vary at different collieries, afford the net advantage of 6d. per ton—that is, assuming the sale of the coal is conducted with judgment and discretion. It might be possible, after screening the coal, to give it away, and so the public would obtain the better results, and not the colliery proprietor. This I should stigmatise as very bad management. As I have stated, the percentages of the various sizes differ so much that it is impossible to give any reliable figures. The percentages of large coal vary from 45 per cent. to 65 per cent—I mean round, best house coal—in the districts I am speaking of, but I know districts where the percentage of large best coal is not 10 per cent. In the Hoyland Silkstone Collieries the Silkstone seam does not realise 10 per cent. of house coal.

9923. (*Mr. Briggs.*) Might I ask what depth Hoyland is?—530 yards, but I know where the same seam is at the same depth nearly, and where better percentages of large coal are obtained. The seam lies between faults, and whether that has any effect in causing greater pressure I cannot tell you.

9924. (*Sir George Armytage.*) What saving is made per ton in handling by the new compared with the old arrangements?—The saving per ton in handling by the new as compared with the old arrangements under the best conditions is, as I have stated, about 6d. per ton; that is, increased profit. The cost of labour to produce this is from 1d. to 2d. greater.

9925. (*Mr. Briggs.*) Including interest?—Yes.

9926. That would leave you 4d. net?—That is so.

9927. (*Sir George Armytage.*) How is the large coal treated to prevent breakage in loading?—The large coal is treated in the following manner to prevent breakage in loading. It falls on to a picking belt from the screens by gradual descent. After the picking is considered to be sufficiently efficient, the screen is depressed at an angle which causes it to fall into the wagons with a very little drop. By this arrangement the end of the belt can be inclined so as to go right into the inside of the empty wagon in the first instance. As the wagon is loaded that inclined belt is raised until, when the wagon is nearly filled, the latter end of the belt is practically level again. There are other means of doing this by what you might call self-opening buckets, which open by their own gravity, or by arranged eccentrics. I do not like these, because they are not quick enough.

9928. Then what is done with the small?—The small coal is very often to a great extent used in the boilers of large collieries; where it is of a bituminous character it is coked.

9929. If it is washed, will you give a description of the process?—The washeries that I am accustomed to are the Luhrig, the Humboldt, and the Sheppard, and there is the Murton and the gravitation trough. The principle of all those washers is the difference between the specific gravity of the coal and the specific gravity of the dirt or impurity. The coal rises to the top and the dirt sinks to the bottom of the washer. As I say, there are also trough washers by gravitation as distinguished from the bashers, which might include the Humboldt, the Sheppard, and the Luhrig. The Murton is a washer in which the travel of the belt containing the coal is against the flow of the water; the coal is washed over and falls into a hopper; the dirt which is there stops in the little belts or hoppers—chambers in the belt—and is tipped over at the top; it is the same principle there exactly—it is one of gravitation, only it is a different adaptation of it.

9930. How many and what are the sizes of the marketable small coal after washing, and what are the percentages of these?—I do not know anybody who is washing much round coal, but I have no doubt it is done. What I do where I am consulted and where I have experience, is to wash nothing larger than nuts, and in many cases the nuts and the pea nuts are taken out before the coal is washed. Nuts and pea nuts are being washed at various collieries for steam purposes, and the smudge is sold for what it can realise; because the question arises which was raised this morning, that this steam coal dust is very inferior in the coal which I have in my mind, and it will not compete with very large quantities of very much better slack, and therefore at present has little or no value. In these cases the washing of the various kinds of nuts and pea nuts are separate, the nuts being taken out and the pea nuts passing into the washer. Where nuts and pea nuts are washed for steam or house purposes, as a general result the nuts are about two-thirds and the pea nuts about one-third of the aggregate outturn of the two classes; that is, if you took 100 tons of mixed nuts and pea nuts you would have 66 per cent. and 33 per cent. about. I am not sure that I ought to give you that as an absolute fact, because it will vary with the nature of the mine. Some mines make more nuts and less pea nuts; some mines make more round coal, very few nuts, and some pea nuts. The dirt washed out of coal varies with the purity of the coal. I know places where the washing takes as much as 15 per cent. of dirt out of the nuts and pea nuts.

9931. What are the respective values per ton?—Washed nuts ought to be worth, if bituminous coal, anything from 9s. to 10s. in the market; when I say "bituminous," I mean good house coal. Pea nuts from 8s. 3d. to 9s. If sold for steam purposes they would not realise more than 6s. or 7s. at the outside, either of them.

9932. (*Mr. Young.*) You mean at present prices?—I am taking the prices of to-day. It is difficult to determine the value of the same coal unwashed. There are cases where it is so dirty that it cannot be sold except at a very low price.

9933. (*Sir George Armytage.*) What is the value of the same small coal unwashed?—The small coal (or slack) which I could only sell at about 3s. 6d unwashed or unseparated, I can now sell washed and separated as nuts and pea nuts, at 6s. and 4s. 6d. respectively, or an average of 5s. 6d. per ton, as against 3s. 6d. per ton if sold as slack; so that there is a clear gain of 2s.

9934. Will you state if by the above and other processes coal of inferior quality and seams mixed with

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bands of dirt can be made marketable and of value?—The advantage to be gained by washing would vary with the nature of the coal and the markets using such produce. In large towns where the cost of carting ashes from the boilers of the works is a very serious consideration, it is manifest that the purest coals would compete best in the market, from the fact that the less cartage of ashes means a considerable saving, and the manufacturer who uses the produce can pay a better price for purer coals as compared with inferior coals. Now to give you facts: from the same seam, from collieries not more than three miles from one another, the washed produce is fetching 2s. per ton more than the unwashed produce from the same seam.

9935. Has the result in your district been to enable seams of coal to be worked which formerly were considered of no value?—Yes, picking belts as now arranged enable coals of inferior quality and seams mixed with bands of dirt to be marketable and of value, whereas formerly they were not considered workable. I could name a lot of mines that were not worked, both in Wigan and Yorkshire, which are now being worked by means of these better arranged picking belts.

9936. What are the markets for washed coal?—The markets for the washed coal are, first of all, the coke ovens and large towns and commercial centres where manufactures are carried on.

9937. How is coal prepared for coking in your district?—Coal for coking is prepared in several ways in the districts of which I have knowledge. There are processes by which the bye-products are realised, and of these the Simon-Carvès process may be taken as typical. Here the coal is either washed or not, according to its purity, ground very fine, and put into vessels where it is pounded into cake, and then moved to the ovens and pushed in by a ram. The door of the oven is then dropped sufficiently to allow the ram to be withdrawn and then closed finally, and the process is repeated when the gases have been taken away and the coke has been burned satisfactorily. There are also the Coppée ovens, which are now, so far as I know, as much used as they were years ago; 25 years ago they were all Coppée ovens. The produce is put in in fine dust, and when burned is rammed out by means of hydraulic rams. The Beehive ovens, which seems to make that coke which is most suitable in the outside market by reason of its physical qualities and appearance, are those which I am generally using wherever I am personally making coke. I have not gone into the question of separating bye-products, because I have always been afraid that future competition would lower their prices to such an extent as to set aside any particular advantage to be derived therefrom unless in exceptional cases.

The Beehive oven I am using has a height of 8ft. 3in., and a width of 11ft., and is connected with a main elliptical flue, through which the gases are passed and burned under the boilers which provide steam for the works. I have no fault to find with this class of oven, but of course I am cognisant of the fact that it would be possible to apply even to them apparatus for taking out the bye-products and then passing the remaining gases under the boilers.

It is claimed by the Simon-Carvès Company that the coke made by their process is as good as that made from the Beehive oven. The appearance of coke made by the Simon-Carvès oven is black, and not so good as coke made from the Beehive oven, by reason of its being slacked outside instead of inside, as it is in the case of the latter oven.

From experience I have obtained in the market I am of opinion that coke with the bye-products taken out is not so good as that made in the Beehive oven without the withdrawal of any of the bye-products. At all events, the first named coke, that is, the Simon-Carvès coke, is not so good to sell as the Beehive coke, and I presume that those who use the coke know what suits them best.

9938. Does the recovery of bye-products affect the quality of coke?—The recovery of bye-products does, in my opinion, affect the quality of coke.

9939. To what extent?—I cannot say to what extent, but I should be able to get 1s. to 2s. per ton more for Beehive coke in the districts in which I am selling it than for coke from which the bye-products have been recovered. I think that the coke made from the Coppée ovens without any realisation of bye-products, although not so attractive to the eye, and apparently of the same physical strength, is practically equal in result to the Beehive coke, but at the same time it is only my opinion, and, as a matter of fact, it is never as easy to sell as the bright Beehive coke. Now I have used Coppée coke at iron works, and I have used Beehive coke alongside of it, and I have worked on them for a certain time; I say the Coppée coke produces just as good results as the Beehive coke, but, at the same time, if I had that to sell to the Midland country ironmasters they would not give me so much for it.

9940. Because your experience is that it does not work so well?—The Coppée oven does, so far as I know, but in the Simon-Carvès or any other process where they take the bye-products away, in my opinion the coke is inferior.

9941. Have you made any special test of any quantity that you can compare with the Beehive coke as against the Simon-Carvès?—No, I have never sold any Simon-Carvès coke, but I know of markets where it is competing with me in the Midlands, and I tell you I can get 2s. per ton more; that is the best test.

9942. (*Professor Hull.*) It is used largely for blast iron furnaces?—Yes, I am speaking of that. In the first place it is not of as dense a character; it has not the same physical properties as the Beehive coke.

9943. (*Sir George Armytage.*) Does the value of the bye-products more than counterbalance the depreciation of the coke?—I cannot give you any information as to whether the value of the bye-products counterbalances the depreciation of the coke. I should say it does from the offers which firms like the Simon-Carvès Company made to build ovens, and to deliver them up at the end of a term of years (as a rule 10), provided they can buy the slack of the coking coal at a certain price for that term. This is a very difficult point to decide, because coking firms making such contracts, that is, people like the Simon-Carvès Company, buy their small coal at a very low price over the term of their lease, and if such small coal should rise in the market 1s. or 2s. a ton, in the event of a colliery proprietor coking his own product, the advantage of the bye-products might be eaten away by the rise in value of small coal, whilst a contracting coke-maker who had bargained at a low price for small coal over, say 10 years, would not be interfered with by the rise of the small coal. That is to say, the equation would not be the same as between the contractor who contracts for 10 years at a very low price and then shows a profit—because it is a matter of indifference to him whether the price of coal rises or not, he has it for 10 years—and a colliery proprietor who could sell his slack for 2s. per ton more. It would be really a question to my mind whether the bye-products would give him a corresponding increase over selling it in the open market. I have never known contracts made for small coking coal by such people, that is to say, such people as Simon-Carvès and the others, except at very low prices; so that putting all things together it appears possible for a term of years that the contracting coking company by reason of buying this slack at a low price for a long term of years, may be able to sell their bye-products to advantage, although they have to take a less price for the coke. When they hand the ovens over to the colliery company at the end of the term agreed, the ovens will require more or less repair, and the colliery company would have to consider in any advantage they might gain in the sale of their bye-products, the increased price of their coking slack, and also of course the less value of the coke made in such process. Personally, the investment has never been a tempting one to me, because I have always considered it advisable to sell the produce in as crude a form as I possibly could, and I have only coked coal where I have been obliged to do so by reason of the large quantity of small coal made in the working of the mine and its adaptability to coking.

9944. Will you state generally any other facts on these subjects which you consider may be of value with the view of utilising the coal resources of the country to the fullest extent?—I have before stated in the early part of my evidence that I considered the adaptation of coal-cutting machinery where practicable would bring mines into operation which otherwise would not be worked. The coking of coal is undoubtedly a great advantage, as it enables the colliery proprietor to turn into merchantable produce, that is, coke, small coal which otherwise would in some cases be put on to the pit hill and burned or

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Mr. John Higson.

29 Jan. 1903.

sold at a very low figure. I have known this class of coal to be filled into wagons for nothing if people would take it away, and I have sold hundreds and thousands of tons of very good bituminous dust at 1s. 6d. per ton. I give it to you as a fact that at about 1879 or 1880 I could not sell the best quality of dust at a greater price than 1s. 6d. per ton.

9945. (*Mr. Briggs.*) That is what is described by you as passing through $\frac{3}{8}$in. holes?—Yes. I now realise for the same class of coal, taking into consideration the profits made on coke, an average of about 4s. 6d. per ton, whereas formerly I had to sell it at 1s. 6d. per ton. In other cases where small coal is not so suitable for coking it is being made into briquettes for house and steam purposes, and I am quite certain that this trade will come into great prominence in future. In this country there has been considerable objection to briquettes for house purposes, because of the burning of the pitch which is used in making the briquettes. I have heard of patents whereby some briquettes can be so infused with petroleum as to produce as good results as the best steam coal, if properly used; and it seems to me that in the poorer quarters of large towns where a briquette can be bought for ½d. or 1d., and where there is no small coal or depreciation—that is in buying a load or half a load—this class of fuel will become yearly more popular both for house and steam purposes. Steam coal slack in many cases is not suitable for coking even if thoroughly cleaned and washed. Such coal will make coke, but the coke will not compete with the better qualities, and so the colliery proprietor is obliged to look to the sale of this slack for engine purposes and briquette purposes; and if such briquettes are made judiciously from this inferior coal they will, in my opinion, produce a very good steam producing fuel. I would emphasise that by saying that in Liverpool now there is a trade springing up that is sure to be a very large one in my opinion for these very steam briquettes.

9946. (*Mr. Bell.*) How long has it been going on?—I think about the last 12 or 18 months it has come into prominence, and I am preparing to make a large quantity now.

9947. (*Sir George Armytage.*) Are any collieries with which you are connected making the briquettes?—Yes, house briquettes.

9948. What shape—square?—Oblong—about 2½in. by 1⅝in.

9949. Sharp corners?—Yes. The large expenditure which is made on picking belts and cleaning installations generally enable coal to be sold which otherwise could not be disposed of on the market, and this of course must be a considerable economy in the utilisation of coal which, if it were not so, could not be worked, at all events for a very great many years to come. We are in a transition state now: half of us, or more than half of us, have got this better method of picking and screening the coal, and we are certainly taking the trade from those people who do not screen and do not pick as we do; but when everybody picks and screens pretty nearly equal to one another, I am inclined to think very much that the advantage would be to the general public and not to the colliery proprietor. I do not know whether you agree with that, still it is an economy, because if the public can buy a better coal at the same or less price, they can compete for the benefit of the general public in what they manufacture against all the world.

9950. Do you not think that those things will all regulate themselves according to the law of supply and demand?—Yes; independently of this argument, the price will go up and down, but I am trying to assume an average condition of things.

9951. (*Professor Dixon.*) I do not quite follow your statement about the Simon-Carvès Company when they put up an installation?—They go to colliery proprietors and they say, "Now, if you will adopt our installation for making coke, and will sell us small coal for ten years at X price, we will give you the coke, and after ten years we will hand you over the works for nothing." Therefore they must make a profit theoretically, or they would not offer such a thing. My contention is that the profit arises out of the low price which they pay for the coal.

9952. They hand over the coke to the company, and only keep the bye-products?—That is it. They hand over everything to the colliery company at the end of ten years.

9953. (*Sir George Armytage.*) Who does the work?—They do. Of course you know there has been a great fall in the prices of bye-products; very little benzole is made now even by those who do extract bye-products; they go in for other bye-products of an economical nature. I do not think I am quite competent to deal with that, although I did spend six years in a laboratory. The bodies from which alizarin can be prepared seem to be the favourite thing to-day. Ammonia is one of the coarser bye-products.

9954. (*Dr. Le Neve Foster.*) You say "I know of collieries where on the same pit-head there are at least eight varieties of coal being screened." Do you mean eight varieties being produced from the colliery, or eight seams being treated?—There are eight different varieties of coal made out of the same seam.

9955. Then you give these different names, the cobbles, slack, nuts, etc., can you give the exact sizes of those. I will answer your question if I can. Supposing I was dealing with steam coal in the Midland counties, I should put in different sizes to what I should with a highly bituminous coal like the Haighmoor or the Silkstone seam.

9956. What size do you mean by nuts and pea nuts?—Nuts generally go through an inch square mesh. Pea nuts would be all that remained between the inch and the five-eighths.

9957. What do you call small nuts?—Where they are making small nuts as distinguished from pea nuts, the top end of the screen enables the pea nut to fall through on to the slack belt, which is half an inch, and the slack belt is nearly $\frac{3}{4}$.

9958. The small nut would be $\frac{3}{4}$ to $\frac{5}{8}$?—Yes, I should say $\frac{3}{4}$ to ½ an inch in that case.

9959. What I gather from you is this, that these sizes are not fixed like the laws of the Medes and Persians?—No, not in my experience.

9960. With reference to the Simon-Carvès coke, you say it is not so good in your experience as the Beehive?—I do not think so. I base my judgment on its selling price in the Midland counties.

9961. Have you had it analysed at all?—No, I have not; I am merely speaking of it as a saleable article.

9962. (*Mr. J. S. Dixon.*) You stated the price of slack to be 3s. 6d., and after treating it and making it into nuts it would realise 5s. 6d. There is a certain amount of loss there, is there not? There is the washing?—I do not wash it. It is a very fine bituminous coal.

9963. You do not remove any dirt out of it?—No. Where we do wash we lose, I think, in one case about 10 per cent. in the washing.

9964. That would reduce the advantage?—Yes.

9965. (*Mr. Young.*) What would the 2s. on the small alone amount to on the total produce?—By making a variety such as coal cobbles, pea nuts and dust, we get as much for 80 per cent. as we got for the whole amount, leaving me my 19 2s. 6d.'s, which, on the general average selling price makes 5⅜d. a ton increase.

9966. Will there be any cost at all to add against that profit?—Yes; you may take 2d. off it, so that you get a net gain of about 3d. per ton.

9967. (*Mr. Bell.*) I want to ask a question upon this briquette matter. You say in some cases where small coal is not so suitable for coking it is made into briquettes for house and steam purposes. How long has this process of making briquettes for house purposes been in operation within your experience?—Seven or eight years.

9968. Do you find that the people appreciate them?—They do not gush at them.

9969. It seems to be theoretically a very excellent idea to make the small coal into the briquettes for house purposes, but do you know of any instances within the last ten years, for example, where colliery proprietors who have found difficulties in disposing of their small coal have turned their attention to briquettes, expecting that, in the immediate locality of large towns, people would gush at them, and they have not done so?—I do.

9970. And that plant has been really abandoned?—I do not know of any plant abandoned, but I know where plants have not been the success they ought to have been. Every year you must either go backwards or forwards. I think we are going forwards in recognising that Continental nations have taught us that if we are to

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make our produce economically useful, and therefore merchantable, we must send it out in the various forms possible. People who made briquettes out of very small coal made it generally from a quality of coal that they could not sell at any price as slack, therefore it was worse coal when it went into the market as briquettes, because they were sending it to a critical market—for household purposes. Had they taken a coal which was adaptable to briquette making for house purposes, I think it would have been a success, and I think they have done more than anyone else to injure the trade. I go a great deal abroad, and I feel certain that to France alone I can sell every steam briquette I can make.

9971. My question is confined to the appreciation of the British householder, and especially the poor class of British householder, who have had these briquettes offered to them, and have not apparently appreciated them?—When these briquettes were first put before the public they were in the shape of bricks, and so dense that they blocked the draught, which was only found out afterwards.

9972. The greatest experience you have had of house briquettes is at Liverpool?—No, I would rather say in Yorkshire.

9973. (*Sir George Armytage.*) Practically you say they are not very readily bought?—Not for house purposes.

9974. (*Mr. Bell.*) You think that is because in the first place they are not made of the best coal, and in the next place they are not perforated, and they do not burn very readily?—Yes.

9975. It is only a question of proper manufacture, and they will be appreciated, you think?—In my opinion, yes.

9976. (*Mr. Brace.*) You say "The coal falls on to a perforated screen, which makes the best coal and cobbles." I presume you pay your men upon the gross weight in the tram?—Yes; we have nothing to do with the different sorts; there is no "Billy Fairplay," or anything of that sort; we simply weigh the coal which comes out of the pit and separate it to suit our market—the collier has nothing to do with that except that we do not want him to send out the dirty holing slack.

9977. You say you have not gone into the question of eparating bye-products, because you have always been afraid that future competition would lower their prices to such an extent as to set aside any particular advantage to be derived therefrom unless in exceptional cases. Now, Mr. Beilby was here giving evidence yesterday, and he is a great authority upon bye-products?—Well, I am not.

9978. I am simply going to put this to you now, that he gives an exactly opposite opinion?—He is a great authority. I should attach much more importance to his evidence than my own. All I know is this, that a neighbouring colliery working the best quality of bituminous coal had their bye-products works standing for several years. They must have spent £40,000 upon them.

9979. (*Mr. Bell.*) How long is it since they were put up?—They are working again now. They were put up in 1883.

Mr. John Higson.
29 Jan. 1903.

9980. (*Mr. Brace.*) What is the lowest thickness of coal that you think might be worked at a profit with coal-cutting machines?—Well, I am working one 20in. now.

9981. What kind of machines are you using?—I am using a great many. I am using the Belgian cutter, the Yorkshire Engine Co.'s machine, the Clarke and Stevenson machine, the Jeffries' machine, and the Champion Drill Co.'s machine—I cannot remember how many.

9982. You are able by the use of these machines to work a seam 20in. that would be absolutely impossible by hand labour?—I could not get the men in; there are so many thicker seams about. If you have men who have been working a 7ft. or 6ft. seam they would not look at a 20in. seam.

9983. (*Sir George Armytage.*) There are many seams being worked of 20in.?—Yes, in your country; there is the Better bed. The Black Bed Seam of coal also is being worked there at 2ft. 3in., or 2ft. 4in., and when the seam becomes thicker it deteriorates. Whenever I want a good collier I always try and get him from that country, because if you get a man who has worked in 7ft. of coal he is no use at all for a thin seam.

9984. (*Mr. Brace.*) That is not quite an answer to my question. You say you work seams now of 20in. with machines?—I do.

9985. If labour was plentiful and men had been trained to work the thin seams, there is no physical impossibility in having that seam worked at a profit by hand labour?—No, if you have all good holing and good roof. There are some seams where a collier will not face the holing; when the pick rings and does not make any effect the collier will not face it; but there may be cases where he would work.

9986. I will tell you what is in my mind, and then you can answer it. There are some seams of coal so thin in this country at the present time that they cannot be worked at a profit with hand labour. You say you have a lot of experience in cutting coal with machines. I am asking you now to tell us what is the thinnest seam you think could be worked at a profit by the use of machines, that would be valueless, if you were to depend upon hand labour?—Well, if it is a very high class quality, and there is an exceptional market, I would face a 15in. seam if the holing was good and the market was good. It must be assumed that with a 15in. seam you are going to cut 4in. more, that would be 19in.

9987. (*Sir George Armytage.*) Can you tell us what class of power you are using for these machines?—Electricity and compressed air. Where mines are very fiery, personally I will not accept the responsibility of electricity. Where the mines are not fiery and have damp floors and roof, I might accept responsibility. Electric power is best adapted for coal cutting but for the difficulty of short circuiting and blazing in the faces.

9988. It comes to this, where it is safe you would rather use electricity?—Yes, but in most mines I should be very shy about putting it in.

Mr. WILLIAM COLQUHOUN, A.M.I.C.E., called; and Examined.

(*Witness read the following statement.*)

Mr. William Colquhoun, A.M.I.C.E.
29 Jan. 1903.

9989. (1.) I am an engineer, and in that capacity have worked on the question of the production of briquette fuel and its machinery. As the result of visits to the Continent I have had occasion to report several times on the use especially of washed slack for that purpose, a practice that does not obtain in this country.

(2.) The output in England is comparatively restricted, having been estimated at about 800,000 tons per annum. Nearly the whole is exported, chiefly for use on foreign railways, the domestic consumption being insignificant.

(3.) The home of the industry in England is in South Wales, where the small coal is distinguished by its freedom from dirt. Briquettes from that district share in foreign countries the reputation for steam raising purposes enjoyed by the coals from which they are derived. The demand is for use chiefly on the Mexican, Italian and other Continental railways, and in foreign navies.

(4). The industry in this country suffers under the disadvantage that the undertakings are rarely associated directly with the colliery, sharing its charges for site, management, fuel, etc., but exist as separate small concerns of limited capacity, bearing the high charges incident to a site near the port of shipment. Further, these concerns buy in the open market only unwashed coals sufficiently clean for their purpose, none using washed slack, except in some instances where as much washed slack is added to the dry coal as will not increase the contents of moisture above the amount a good briquette will carry. In these two respects—association with a colliery and the use of washed slack — English practice differs from that in Belgium and France.

(5.) It is admitted that in many instances it may be more profitable to make coke rather than briquettes, but on the other hand the greater part of the small coal produced, or that cannot be properly mined, in this country, is unsuited for conversion into coke. Such coal

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Mr. William Colquhoun, A.M.I.C.E.

29 Jan. 1903.

may be briquetted at a substantial profit if there exists a demand for briquettes. In that form it has advantages. It is no longer subject to deterioration. For its weight it occupies 14 per cent. less space than large coal, and is cleaner, features having value in navies. If derived from bituminous or semi-bituminous seams it is not at all objectionable for domestic purposes. For steam raising it is only 6 to 8 per cent. inferior to the parent coal in evaporative value.

(6.) Slacks of either a dirty or exceptionally dusty character cannot profitably be made into briquettes (except under special local conditions), the first because of its low calorific value, and the second because of the large quantity of agglomerating material required to make it cohere.

(7.) Necessity compels the use of washed slack on the Continent, since their small coal is too dirty to use unwashed. The maximum amount of moisture permissible is 5 per cent., and washed slack is rendered suitable for making briquettes only by drying. Nothing is gained by draining ordinary screen slack that has been washed for a longer period than 24 hours, when it still contains a prohibitive quantity of moisture. Of the many artificial means on the Continent of drying off the moisture the apparatus most generally accepted is the Biétrix furnace, of which some 250 are in operation. The cost of reducing the moisture from 10 down to 4 per cent. by this operation is 3d. to 4d. per ton, including fuel, power, labour, and interest on outlay. Against this there is a variable saving in the amount of the agglomerating pitch used, owing to the temperature of the coal being raised sufficiently to facilitate the intimacy of contact between the coal particles and the pitch.

(8.) The process of manufacture is well understood. The small coal is mixed mechanically with the proportion of pitch it demands, the mixture is broken up together in a disintegrator, and is then passed through a steam-heated pug-mill, and delivered to the press.

(9.) The finished briquette may weigh from a few ounces up to 28lb. according to the market for which it is destined.

(10.) The agglomerating agent used is pitch, derived from the distillation of coal tar, the quantity required being influenced chiefly by the state of division of the small coal, and varying from between 7 and 10 per cent. It has been, and is, a favourite field for inventors to find a more economical substitute for pitch, and there have been an enormous number of patents in this direction, but none have succeeded commercially except under abnormal local conditions.

(11.) The cost of manufacture varies, according to the size and nature of the plant, between 6d. and 9d. per ton for labour, 4d. and 7d. for stores and repairs, and 3d. and 6d. for interest and depreciation. With small coal at 6s. per ton, and pitch at 58s. per ton, the cost of the briquettes should not exceed 11s. 6d. to 12s. per ton in a well-found plant. To this has to be added the cost of distribution.

(12.) Coke breeze is successfully made into briquettes at several Continental gas works by the use of tar or pitch or both, for their own consumption under the retorts.

9989.* (*Sir George Armytage.*) Is there anything you would like to add to that?—I would like to say in reference to the cost of manufacture that the price of pitch at the present moment is altogether abnormal, and nothing has ever approached it before, or ever will again probably. The high price at which I have taken it (58s.) is no longer true; 55s. would be more correct. Ordinarily it is 30s. a ton.

9990. You say these briquettes are made from a few ounces up to 28lbs. in weight. What are those 28lbs. in weight used for?—28lbs. happens to be the weight that the Natives will carry. Those particular briquettes would go to the West Indies.

9991. What are they used there for?—In factories for steam raising.

9992. Have they to break them before use?—Yes, they are broken up.

9993. They are put in this shape for portability, and also for one man carrying them?—Yes, it forms the burden of a Native.

9994. And loading and unloading?—Yes. They are, as a rule, unloaded by Natives on planks.

9995. Have you had practical experience of the manufacture?—I am connected with it solely as an engineer.

9996. In setting up plant and that sort of thing?—Yes.

9997. Some of these briquettes are for household use?—Yes.

9998. In what shape are they made?—In this country the household consumption is very limited. There are now, I believe, no places in England where they are not made in the shape of small bricks with square corners.

9999. And perforated?—In some few instances.

10000. You do not know of any made round or egg-shaped?—Not now. The only one place I did know of where they made them egg-shaped has stopped through financial difficulties.

10001. Is there any more difficulty in making them round or egg-shaped than square?—Yes, they are more costly. The increased cost arises from the fact that they are made by a rotary motion, and that motion is very destructive to the material; it has to be loaded up with a larger quantity of pitch, and there are more breakages in the manufacture.

10002. Can you give us any idea as to why these have not got a better market in England?—So far as use for household purposes is concerned I can understand they are open to very grave objection in a town, because they increase the smoke.

10003. They are dusty?—No, they increase the smoke nuisance.

10004. Owing to the large quantity of pitch?—Yes.

10005. What other mediums are suggested. You say patents have been taken out for holding the dust together by other materials besides pitch?—A great many, but the most popular is the starchy product of grain refuse, sweepings of mills and so on, and some roots like potatoes.

10006. Lime?—Lime is used by itself, and in conjunction with this farina or starch. Lime, however, adds ash to the briquette.

10007. Are these briquettes very easy to light?—It depends a good deal on the nature of the coal from which the small comes. If it is a bituminous house-coal it would light quite freely—flame. They burn very dead if of dry steam quality.

10008. Most of them are made from steam coal, I suppose?—Yes; they are used for steam purposes.

10009. Can the briquettes made in England compete with those made on the Continent?—In price?

10010. Yes—there?—No, not there. For instance, a briquette made in Belgium is cheaper than we could send it to Belgium for; but we could send to Italy at a cheaper rate.

10011. It is cheaper for a Belgian to use a Belgian one than to use an English one, and cheaper for an Englishman to use an English one than a Belgian one?—Yes, that is true.

10012. (*Mr. Brace.*) When you go to Italy for an Italian to purchase a briquette it is cheaper for him to purchase the British briquette than the Belgian briquette?—Yes, that is so.

10013. (*Dr. Le Neve Foster.*) Have these egg-shaped briquettes been made in South Wales quite lately?—It is quite possible; I am not aware of it.

10014. When were the works to which you refer given up?—Some years ago now. I do not know any reason why; I could not tell you. They were at Walnut Tree in South Wales. They might have restarted, but I do not know anything more about them.

10015. So far as you are aware they were given up because the product did not sell commercially?—I do not know for what reason they gave up. The cost of manufacture was too great for them to succeed, I presume.

10016. Did you ever try any of these yourself?—No, but I have been in a room very often where they were used on a fire, and they make an excellent fire.

10017. I have tried some of the South Wales myself at home, and I thought they were still being made?—It is quite possible.

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10018. (*Mr. Brace.*) Not perhaps in those works at Walnut Tree, but since then I know one briquette establishment within the last three or four years that has been erected, and is working satisfactorily and successfully?—That is possibly so.

10019. (*Dr. Le Neve Foster.*) Are not these egg-shaped ones successfully used on the Continent, and liked?—Yes, in some instances they are made not only egg-shaped, but perforated.

10020. Small ones perforated?—Yes.

10021. Is there any reason why they should not be liked here, beyond the question of smoke of which you have spoken?—The price of briquettes has never been sufficiently below the price of good coal to induce people to buy freely.

10022. Ought the buyer to expect them to be less than good coal if he gets an equally good fuel?—Yes. It comes back to my argument that if a modern plant were erected, thoroughly well done and erected in connection with the colliery, I do not see any reason at all why they should not be many shillings below the price of large coal.

10023. Is it not a convenience to the householder for domestic purposes to have a clean fuel of this description?—Yes.

10024. Is it not a fact that one's servants have to break up the large lumps of coal?—That applies to briquettes too.

10025. There are some made fist size, for instance?—The ovoids are more expensive to make than the others. If you have a brick of the usual size, and it is sufficiently clearly marked with a cross, it breaks quite readily.

10026. (*Sir George Armytage.*) For all that, it makes dust by breaking?—Yes, the loss is greater through it.

10027. What physical difficulty is there in making the briquettes of the right size you want, about the size of your fist, or whatever it may be for domestic purposes?—There is no physical difficulty.

10028. To what extent would they be more expensive than if made in larger blocks?—They would have to carry at least 2 per cent. more pitch, which is the heaviest item. Taking the pitch at a reasonable price, it would mean adding 6d. a ton.

10029. Do you mean when small they require more pitch than when large?—I would not say that; but owing to the method of manufacture more pitch is necessary. The ordinary square briquette is made by compressing it in a mould with a ram; but an ovoid is made by rolling contact, and it easily disintegrates unless it carries more pitch.

10030. (*Dr. Le Neve Foster.*) Is pitch, in your opinion, the only cementing material than can be applied?—It comes to this that in the face of all attempts nothing else is used successfully except in a very small way.

10031. With reference to another form of coal which really does not affect us in England, have you had anv experience with the manufacture of brown coal briquettes?—No.

10032. Do you know they are very much liked in Holland by the people there for house use?—Yes, they are so remarkably clean and they appeal to the Hollanders for that reason.

10033. (*Mr. Young.*) Does perforating improve the briquettes very much?—I do not attach great value to the perforation; you arrive at the same advantage by keeping the briquette small. Perforation, again, like making ovoids, adds to the cost of the briquette. To have a perforated briquette adds to the cost.

10034. Would perforating increase the cost as much as making them small rather than large? It would all be done in one process?—It is done in one process, it is true, but the insertion of the pin into the material for the purpose of making the perforation breaks up the material more, and for that reason the perforated briquettes have to have more pitch than a plain briquette. A coal that would make a perfect briquette with 8 per cent. of pitch would possibly not stand perforation.

10035. (*Mr. Bell.*) Do those briquettes, not having any fracture, break pretty readily in the fire?—Yes, they break fairly readily; it depends a good deal on the pressure that is used in the manufacture.

10036. Are you speaking of those briquettes which are being made to-day, and do you consider that there is any material improvement in that direction in the power of producing briquettes for domestic purposes during the last few years?—I do not think there is any improvement during the last 10 or 15 years; it has been at a standstill. *Mr. William Colquhoun*, A.M.I.C.E. 29 Jan. 1903.

10037. I do not know whether you are aware that there were some attempts to introduce these briquettes, and they were sold in large towns at 1d. apiece in the brick-shaped form, and they were not a success?—I know that has been a common occurrence, and that they are a perfect success under the same conditions on the Continent.

10038. For domestic purposes?—Domestic purposes. In Germany, I believe the domestic consumption absorbs 29 per cent. of the total make. I believe that they consume for domestic purposes considerably more than we make for export.

10039. They burn them in stoves there?—Yes.

10040. Have they more draught there?—I presume the closed stove has more draught.

10041. You do not see any reason why they should not be appreciated for domestic purposes in an open grate?—No; I know houses where they are used, and there is no trouble.

10042. Do you know why many of the Continental railways do apparently appreciate the briquettes and some do not? For instance, Italy consumes on railways a very large quantity?—One can understand Italy doing it: it costs less to take the briquette into the country.

10043. They make them there as well?—Yes, they make them there, but when we commenced to export to Italy they did not make them there.

10044. You think they find it cheaper to import the coal?—I think they find it cheaper to import the briquette than the coal.

10045. They are not importing South Wales briquettes into Italy in any large quantity, are they?—I was under the impression that they were.

10046. You cannot give shortly any special reason why you think the railways in some countries do appreciate briquettes apparently, and in some countries they do not. Do they stand the weather better?—Is that not a sufficient reason? It is a fact that they do not deteriorate. If you stack large quantities of briquettes they are equally good in five years as in the first year.

10047. At all events, briquette-making in this country for domestic purposes is quite a new idea, is it not?—Yes.

10048. You think from your knowledge of the manufacture and general composition of them, it is an idea which will grow into use?—Yes; I think that if the conditions of manufacture enabled briquettes to be offered at a sufficiently low price, they would be more commonly used for domestic purposes.

10049. Do you know anything about this petroleum refuse which has been spoken of?—I know it is one of the agglomerating agents, but I know nothing of it.

10050. (*Mr. Brace.*) Have you had any experience in the making of briquettes with something other than coal—say, peat or turf?—No.

10051. I notice that you say that pitch for the making of briquettes was selling at 55s. a ton. In a United States Consular Report from Germany, dated August 16th, 1902, the cost of pitch there is given at £2 per ton. Is pitch dearer in this country than in Germany?—At the present moment it is; it has never been so before.

10052. The great fault or a great disadvantage of briquettes for household purposes appears to be the smoke?—The smoke outside; that is to say, not in the room.

10053. (*Sir George Armytage.*) Black smoke from the chimney?—Yes.

10054. (*Mr. Brace.*) I daresay you may think this is a silly question to you from a lay mind, but supposing that the bituminous coal could be brought to a kind of boiling point, which it is in the process of coke making, could some method be adopted for moulding that coal in that state into briquettes, and thereby do away with the necessity of having to add pitch to it afterwards, as

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Mr. William Colquhoun, A.M.I.C.E.

29 Jan. 1903.

you have to do now in its raw state?—It is impossible to stop short at the point at which you volatilise the lighter constituents of the coal. At the same time there is something in what you suggest, because on the Continent the drying process adopted aims at that, and to some extent it reduces the amount of pitch necessary.

10055. It does seem to me it is in that direction that the solution of the smoke problem in briquettes will be found?—If any other agents than pitch could be found that did not add to the natural smoke of the coal that would solve the problem.

10056. For the present you know of no other satisfactory agent?—No.

10057. Take many of the German towns that use briquettes very largely. I understand that they are pretty free from smoke. Would you put it down that the difference is to be found in the stoves as against our open grates?—No. Take a town like Dusseldorf, for instance. It would be very difficult to make it dirty, even if every house was burning briquettes, but it would be different in London.

10058. Take Berlin?—Briquettes are not universally used in Berlin by any means.

10059. But still they are used in pretty large quantities there?—Yes; but they are made of lignite, which does not smoke so much.

10060. Yet Berlin is very free from smoke, is it not?—Yes.

10061. (*Sir George Armytage.*) A great many of these briquettes are used on the foreign railways, are they not?—Yes.

10062. You see them stacked by the side of the engine-sheds and so forth. Do they depreciate at all in time?—No.

10063. They stand the weather well?—Yes.

10064. And stand frost?—Yes.

10065. And are none the worse if they are used three or four years afterwards?—No, not appreciably worse.

Mr. CHARLES RUDOLPH ALTENHEIM, called; and Examined.

Mr. Charles Rudolph Altenheim.

29 Jan. 1903.

10066. Are you a colliery engineer practising at Sheffield?—Yes.

10067. Are you senior partner in the firm of W. Edward Kochs and Co.?—Yes.

10068. You spent your apprenticeship with the Humboldt Engineering Company of Kalk, near Cologne?—Yes.

10069. Have you a thorough knowledge of all the various designs of coal washing machinery, whether erected by the Humboldt Company or other firms?—Yes.

10070. Have you investigated the best methods of treating dirty and inferior coals with the object of making them marketable?—Yes.

10071. Will you be good enough to elaborate that a little in your own words, and tell us your views on the subject?—In Germany coal is very much inferior to English coal. About 75 per cent. of the coal produced in Germany goes through the washer, and after washing you are able to sell it. The coal breaks to pieces easily, and everything below 4 in. is washed. Four or five different sizes are produced, cobbles, nuts, peas, and coking slack. Some screen the coal first and wash it separately, and others wash it first and screen it afterwards. I think it has been settled now that screening the coal first and washing it afterwards is very much superior, as you get it very much cleaner. It is put into the revolving screens or into shaking screens having several meshes. First, there are holes which retain the biggest size, and then all the smaller drops through, and that is done again, until the fine dust drops through the last screen.

10072. That is practically the same plan as that which is adopted in English collieries?—Yes, but all the good washers are on the Belgian principle.

10073. The prices of those vary according to the size?—Yes; a small washer would not cost very much less in comparison with a big washer. It costs up to £50,000 for a big washer. That is a washer to treat 2,000 to 3,000 tons per day.

10074. Do you find in Germany the various sizes are higher than in England?—They are made into sizes which do not vary very much. I think they get a better price for house coal if mixed from a small size to about the size of peas. There are several different purposes for which they are used. You want them of a uniform size, and you screen them to the desired sizes to get better prices.

10075-6. You say the first cost of washing plants is heavy; but it is economical in view of the considerable amount saved in labour. Can you give us any idea of what the size of one of these large plants is?—We are putting up one in South Wales which I think is the biggest in the United Kingdom, which does 1,600 tons in 10 hours. I think the cost of that plant complete, building and all of it, will be £40,000.

10077. (*Mr. Briggs.*) That is washing alone?—Sizing, washing, storing.

10078. (*Sir George Armytage.*) Is all the coal taken from one colliery?—It is collected from six collieries, I think, but all the collieries belong to the one firm. Part is brought by railway wagons and part by aerial ropeways over the mountains. A big plant does not require much more labour to manipulate than a small one.

10079. Are you also acquainted with the retort ovens?—Yes.

10080. Do you represent the Koppers oven in this country?—Yes.

10081. Will you explain the action of that oven to us?—The Koppers oven is of several types; one is worked without the recovery of bye-products, another is with the recovery of bye-products, but without a regenerator, and another is with a regenerator. The regenerator oven gets all the energy in the coal in the shape of illuminating or inflammable gas. You can use the gas for firing steam boilers, for producing power in gas engines, or for illuminating. In using it in gas engines it is four times as efficient as with steam engines.

10082. You get four times the power out of the gas that you do out of the steam by the consumption of the same quantity of coal?—Yes.

10083. Then what do you say as to the loss of the fixed carbon?—It is very slight; it is almost nothing in coking with retort ovens. It is very heavy in the case of the Beehive ovens. I think the coking in England is very far behind. I know several collieries in the Midlands with Beehive ovens where they coke about 3,000 to 4,000 tons coking slack a week. They have a yield of 47 per cent. I calculate the saving to be effected, by introducing patent ovens, in the shape of surplus energy, and in the shape of inflammable gas, and also the bye-products, would be about £47,000 to £50,000 a year. All the heat produced in the oven is not used even for heating boilers.

10084. What are your figures as to the proportion of carbon and so forth in the average coking coal?—The carbon varies between 65 and 75 per cent.

10085. And ash?—About 5 to 15 per cent., but it is very difficult to say. Some coals have a high percentage of ash; it varies in unwashed coal up to 25 or 30 per cent.

10086. You say, I believe, 25 per cent. of volatile constituents?—Yes.

10087. And from that coal how much coke will be obtained?—About 76 per cent. of coke.

10088. About 15 cwt.?—Yes.

10089. You say the gases are sufficient to enable 2,800lbs. of steam to be raised per ton of coal coked?—Yes; sometimes it is very much higher, but if the gas is produced in a regenerator oven the efficiency would be four times as large.

10090. You have had some experience of Beehive ovens?—I have had a lot to do with them.

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10091. What is your view as to the difference of loss in the Beehive oven as compared with your oven?—In some of the ovens I think they lose about 30 per cent. of the carbon.

10092. That means to say they will not make so much coke by 30 per cent. in their oven as you do out of a ton of coal in your oven?—Yes, if all the coal is turned into coke.

10093. There would be great economy if all coal was made into coke, you think, and if the gas were used for motive power, or lighting, or something of that sort?—Yes, because the coal which would not coke you could turn into small coke, and burn that in special grates under the boiler.

10094. What would be the value of the bye-product recovered from a ton of coal?—It would be up to 5s. per ton of coal coked.

10095. How would you make a good coke with coal which is not usually considered coking coal?—Either mix it with very good coking coal or compress it.

10096. Will you give us your views about that?—If you compress the coal it makes a very hard and very strong coke, and you can use it in blast furnaces, and use a higher blast and bigger weight. Also the amount of coal used per ton of iron will be very much less. It has a great efficiency in heating if the coal is compressed before it is coked.

10097. Have you had much experience in doing that?—Yes, in Germany I have designed many plants for coke-making; using coal which could not be coked and mixing it with a rich coal.

10098. In what proportions?—One in three generally; one part poor coal, two parts rich coal.

10099. That would be at a colliery?—It would be mostly done at the iron works where they brought the coal from the different collieries.

10100. Have you had considerable experience with compressors?—Yes; with several kinds of compressors in use.

10101. What is the cost of them?—The cost is not very great; they save a lot of labour and time in charging the ovens, and the result is that the coke is very much better—better in appearance and stronger—and it does not give so much small coke. One compressing machine, doing about 150 tons of coke per day, costs about £2,500 to £3,000 complete.

10102. I think you have had some experience in briquette-making machinery, have you not?—Yes, I have designed several plants, but I have never been actually engaged in the manufacture of briquettes. I have studied the subject.

10103. You have seen it at work, and made machinery for it?—Yes.

10104. What are your views about briquettes generally? They are used much more on the Continent than here, are they not?—Yes; they have different kinds, made of brown coal, lignite, and ordinary steam coal.

10105. When they are used for household purposes on the Continent, are they used in a square or round shape?—They have egg-shaped briquettes, and square, brick-shaped briquettes.

10106. Is it much more expensive to make the egg-shaped ones than the square ones?—I think it requires more pitch to keep it in its shape, otherwise it would break up in the manufacture. I have seen it in the Humboldt works when they could not get it into an egg-shape at all, as it all broke into pieces when it came out of the press.

10107. Is there much demand for them?—Yes, in Germany.

10108. Do they cause much smoke?—I do not think there is very much smoke if the stove is properly designed and there is sufficient draught.

10109. Is pitch the usual medium for mixing with?—Yes.

10110. Do you know of anything else being used?—No.

10111. Petroleum or lime?—No, I do not know of anything else.

10112. Have you any idea what percentage of pitch is put in?—No; in brown coal briquettes they do not use any binding material at all.

10113. Is there anything else you can think of which will give us some information on this subject we are inquiring into as to the economy of fuel?—In my opinion the only thing is to coke everything, and use the coke for heating, and the gas for lighting or producing power. There are several collieries on the Continent where they do not put up a boiler at all; they drive the whole plant by power derived from the coking installation. *(Mr. Charles Rudolph Altenheim. 29 Jan. 1903.)*

10114. Have you any idea, in round figures, what the advantage would be in carrying that out, taking into consideration everything?—I think there would be a saving of about 10 to 15 per cent. in the working of the plant.

10115. Not more than that?—I am not quite certain; I have not worked it out before.

10116. (*Professor Dixon.*) Have you brought with you any plan of the Koppers' coke oven?—Yes, I have some here.

10117. That is a regenerative coke oven, I suppose?—Yes.

(*The witness produced the plans and explained them to the Commissioners.*) *Supplement Plates, 14, 15, & 16.*

10118. I understand that with this regenerative coke oven you might use about three times the quantity of coal which is ordinarily used in a colliery for power, and do all the work necessary by making coke out of that three times the quantity, and you have the bye-products and the coke over?—All the power produced must be produced in gas engines and turned into electricity.

10119. What power gas engines have you experience with?—Very little experience of gas engines. I have seen several; some 1,500 and 2,000 horse power.

10120. Not in England?—No, in Germany.

10121. How many cylinders would they have?—Only two; and one with 1,500 horse power had four.

10122. There are no installations with two cylinders with 1,500 horse power?—Yes, the Körting system has produced that power with two cylinders. I understand there are also 5,000 horse power engines in America.

10123. Four or five cylinders?—Only two cylinders in vertical engines.

10124. You are not speaking from actual experience?—No.

10125. Are the Koppers regenerative coke ovens working in England now?—No, we only started installing them last year. They are being put up at iron works in Middlesborough.

10126. Which colliery?—At the Weardale Company there is to be a plant of 100 ovens, and they are going to produce 6,000 horse power out of the 100 ovens.

10127. Have you had any experience with the Simon-Carvès?—Yes, I have seen them and spoken to lots of gentlemen who have them.

10128. In what respect is the Koppers oven superior to those?—In the Simon-Carvès there are only one or two points where the flame is formed, and it has to be distributed along one flue before it leaves the oven; therefore the heating is quite unequal. We have a short flame only about 6ft. long in the flues.

10129. You burn your gas nearer to the coal?—Yes.

10130. And with a shorter flame?—Yes.

10131. Does the coke produced in the Koppers regenerative oven compare with the Beehive?—I think it is better in some respects, but you cannot get a silvery appearance with it.

10132-3. Is that more to do with the quenching than the temperature in the oven?—No. If you compress the coal you get the benefit to a much greater extent. I think you can use 5 per cent. more of the coke made of compressed coal than if you use the uncompressed coal.

10134. In your view can such a gas as you can get from one of these Koppers ovens be economically distributed for power from a central station to any distance?—Yes. We know a firm in Durham are going to produce electric power out of coke oven gas. They are going to put a coke oven installation down to take the gas and produce electric power and gas engines.

10135. Distributed over what distance?—For distribution in Cleveland and Durham.

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Mr. Charles Rudolph Altenheim.

29 Jan. 1903.

10136. But the distribution will be electrical?—Yes, electrical. I understand in America they have a lot of coke ovens worked on the same principle; they produce the gas and light the towns with the gas from the regenerator coke ovens.

10137. What is shortly the percentage of combustible matter in your gas in the Koppers oven?—It would be almost the same as gas works gas; there is no difference.

10138. It depends upon the variety of coal?—Yes.

10139. Some have 4 per cent. illuminating hydrocarbons?—Yes. If the gas is required for lighting, then the coking period is divided into two; the gas of the first half is used for lighting gas, and the second half for heating the ovens.

10140. What length is the charge—how many hours?—22 to 35 hours; it depends upon the coal.

10141. And during the first five or six or 10 hours, what happens?—In that case you would have two collecting mains, and take the first half to one plant and produce lighting gas, and the second part you would use for heating the ovens; the benzole and the illuminating power of the gas would be added to the first lot, and that would be getting a very high candle power gas.

10142. You are getting the ammonia out of this as well by washing?—Yes, ammonia and benzole.

10143. Do you scrub it with an acid?—Tar-oil.

10144. No acid?—No, with water and tar-oil.

10145. Have you any experience with producer gas or Mond gas?—No. The coke oven gas is very much richer than producer gas—five or six times as rich.

10146. You mean in thermal units?—Yes.

10147. (*Dr. Le Neve Foster.*) You say in Germany everything below 4in. is washed?—Not in all places; generally, below 3in. is the standard size—some places 4in.

10148. How do you find that compare with washing in England?—I think there is only one place where they wash up to 3in. in England.

10149. What kind of machines do they use for washing these large sizes of 3in. and 4in.?—Similar washing boxes to the usual kinds.

10150. You spoke about the sale of coal in uniform sizes. Does that take place in Germany?—Yes, they always have about four or five sizes of nuts and peas.

10151. You find that an advantage?—Yes; the same with coke. They have about six or seven different sizes of coke, from about ¼in. to 2in. It varies almost to ¼in. difference.

10152. And that affords an advantage in burning?—Yes, in burning for the several different purposes for which it is used.

10153. Would you advise that to be tried in England—Yes, because you get a very much higher price for the small coke than the big coke. There is one big place in Germany producing about 400 tons a day; they break everything they produce, and sell it in different sizes of nuts and peas.

10154. Do purchasers find that an advantage?—Yes.

10155. You say you advise all coal to be coked. I do not quite understand what you would do with the coal which is non-coking coal and will not coke?—Even that coal will give off gas, and then, when all the gas is given off, the remainder should be taken out and put under the boilers having a very fine grate, and it would produce the same amount of steam as if the coal had been put under the boilers.

10156. You would then get a gas and bye-products and fine coke?—Yes, a very fine coke, almost like dust.

10157. Which you would use for boiler purposes in a special grate?—And forced draught.

10158. (*Professor Dixon.*) Could you give the Commission any idea as to the cost of the installation of these ovens?—A plant of about 100 ovens, producing 450 tons a day of coke, would cost between £60,000 and £70,000.

10159. Your firm are prepared to put them up?—Yes; the profits made would pay for a plant of that size in about two or three years' time.

10160. (*Mr. Young.*) You stated that you were erecting washing plant in Wales, and the cost would be about £40,000, and that it will wash about 1,600 tons a day?—Yes.

10161. Can you state what face value will be given to that 1,600 tons after the cost of washing has taken place, and the loss in washing?—I estimate the cost of washing to be about 3d. per ton; the loss in washing would be represented by the dirt eliminated. No appreciable loss of coal takes place in washing.

10162. Is it not a dry steam coal?—Dry steam coal; it is all taken away in steamers, and it is not used for coking purposes.

10163. (*Mr. Brace.*) Is it at Aberaman you are putting it up?—Yes; therefore you would have to throw the small coal away or sell it at a very low price for briquette-making.

10164. (*Mr. Young.*) You stated also that the value of the briquettes would be at least 2s. 6d. a ton, running up to 5s. a ton?—That is clear profit after all the expenses have been deducted.

10165. (*Mr. Brace.*) Do you know of any system, other than washing, for cleaning coal—of course, I mean a successful system?—No, I do not know of any process; they have used air for separating small coal and dust, or to blow off the small particles of coal from the shale, but never got a good result; and also it is detrimental to the coal if the coal has to be coked.

10166. So that washing is the most satisfactory system you know?—Yes.

10167. Do you know the system of washing adopted by one of the firms in Scotland, Messrs. Campbell, Binnie & Co., which is an improvement on the Luhrig system of washing?—Yes.

10168. Would you say that that improved method upon the Luhrig system would be equally as good as the German system you mentioned, or the Belgian. I think you said?—I do not know that system of Campbell and Binnie; I only know that they make a coal-washer. The greatest difficulty in coal-washing is the slurry in the water. Up to recently they could not screen coal below the twentieth part of an inch, but now a screen has been invented to screen it to below one-twentieth part of an inch.

10169. The coal that has to be washed in the plant you are erecting at Aberaman is a non-coking coal altogether?—Yes.

10170. And that washing is simply to make the coal a better marketable coal in its raw state?—Yes.

10171. So that, even when you have a non-coking coal, washing is an improvement for steam purposes alone?—Yes, because we know that with a plant put up in Yorkshire for washing, they used to use all the unwashed coal for the boilers, and they had to clean out the fires four or five times a day, whereas when washed coal was used they only required to do so once a day.

10172. (*Sir George Armytage.*) Do I understand you to say that this large plant of 100 ovens will produce 6,000 horse power?—100 ovens will produce 6,000 horse power.

10173. By means of gas engines?—Yes.

10174. How many engines?—You would divide that up into about twelve 500 horse power engines.

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SEVENTEENTH DAY.

Tuesday, 24th February 1903.

PRESENT:

The CHAIRMAN.

Sir GEORGE ARMYTAGE.
Sir LINDSAY WOOD.
Mr. BELL.
Mr. BRACE.
Professor DIXON.
Mr. J. S. DIXON.
Dr. LE NEVE FOSTER.
Professor HULL.
Professor LAPWORTH.
Mr. SOPWITH.
Mr. TEALL.
Mr. YOUNG.

The SECRETARY.
The ASSISTANT SECRETARY.

Mr. JOHN PROCTER EELES, called; and Examined.

Mr. John Procter Eeles.

24 Feb. 1903.

10175. (*Chairman.*) You are, I understand, a Colliery Sales Agent, representing collieries in Monmouthshire?—Yes.

10176. Do these collieries transact a large amount of business?—Yes, exceeding half a million tons per annum.

10177. What are the kinds of coal they produce?—Principally steam coal, suitable for locomotive purposes and for the bunkers of steamships.

10178. Is it of the anthracite character?—No, semi-bituminous.

10179. You have had a large experience of the Monmouthshire coal trade?—I have had 15 years' experience of Monmouthshire coal in my capacity as sales agent.

10180. What is the total production of coal in Monmouthshire?—Roughly, about 10,000,000 tons per annum.

10181. It is mainly of the semi-bituminous character, is it not?—Mainly of the semi-bituminous character.

10182. Is a lot of it small?—I estimate, on an average, that the percentage of small coal from the Monmouthshire valleys is about 25 per cent., that is taking the larger percentage of small coal worked in the upper measures together with the smaller percentage of small coal worked in the lower measures.

10183. And speaking of the small in that connection, you refer to the small that is brought to the surface?—Yes.

10184. Is it all brought to the surface?—Unfortunately, no.

10185. Why is it not?—The system of the payment of wages of pit-men in South Wales precludes the full production of small coal being made, the pit-men being only paid upon the large quantity of coal which they bring to bank.

10186. When you say "precludes," do you put it quite as high as that; it discourages it, at all events?—Yes, it discourages it, certainly.

10187. We have had a good deal of evidence upon that point. May I take it that you would agree with this view, that the origin of that was in order to obtain as large a proportion of large coal as possible?—Undoubtedly.

10188. And to avoid making small?—Undoubtedly.

10189. And that that arose at a time when small was of little value?—That is so.

10190. Would you say there is any alteration going on in that respect?—Certainly, as far as the small coal of Monmouthshire is concerned there are now many more extended uses for it, and a much readier sale than there was during the time that this system for the payment of the men upon large coal only was in vogue.

10191. But does that method of payment obtain in the case of bituminous coal?—Yes, almost exclusively.

10192. And throughout Monmouthshire?—Throughout Monmouthshire, with one or two trifling exceptions.

10193. What had you in mind when you, in speaking of small coal, said that you included the small coal which was got from the upper and the small coal got from the lower? I rather gathered from that that you intended to convey that the system of payment was different in regard to the one kind of coal to that of the other?—It is, to a very limited extent; but by far the greater majority of coals in Monmouthshire are of the good class of steam coal, and it is to that particular class that I refer. The system in vogue in some of the little collieries, some of the levels, the coal from which is practically used for household purposes only, is that the men are paid upon the through and through basis, or upon the run of mine basis, and not upon large only.

10194. My only object was to see if I could gather a clear and broad distinction between the kind of coal which is got, and which is paid for, as you say, as through and through, and that which is paid for as large only. I am speaking now of Monmouthshire, and I wish to keep to Monmouthshire?—Yes. Do you refer to a broad distinction in regard to percentage?

10195. I will put it in this way: with regard to Monmouthshire, as I gather from you, it cannot be said that the rule is absolute to pay only on the large coal?—Oh no, not absolute.

10196. Nor, on the other hand, can it be said, as I understand, that the rule to pay only on the large coal applies to all coal of one particular description?—No, not exclusively, but almost exclusively.

10197. Have you in your mind any general figure which you would say applies to Monmouthshire at large?—Amongst the large collieries I only have in my mind one particular colliery at the moment, where the men are paid upon the through and through basis. Apart from that, I believe the other rule almost exclusively applies to the county, that is to say, to pay the men upon the large coal that they fill.

10198. In your opinion, does the fact of paying on the large coal only tend to encourage the leaving of small coal in the pit?—Oh, yes, that is the object of it.

10199. If they could get it all large, of course, the question would not arise?—No, it would not arise.

10200. Therefore the main object is to discourage making small?—Quite so.

10201. And the penalty is that if they bring it to the surface they do not get paid for it?—That is so.

10202. Have you any knowledge as to what one may call the percentage of total get of coal which, in these large collieries, is left in in the shape of small coal?—You mean that is left in the workings? I have not the least knowledge on that subject.

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Mr. John Procter Eeles.

24 Feb. 1903.

10203. Your experience rather relates to the commercial side than to the working side?—Yes, almost exclusively to the commercial side.

10204. With regard to the use of this coal for the bunkers of steamers, has there been in recent years an increasing use of small coal?—That is my experience.

10205. And you are still, of course, adhering to Monmouthshire coal in saying that?—Yes, but this relates also, I may say, to most of the steam coals of South Wales apart from the Monmouthshire coals.

10206. Is that change due to the fact that they get it cheaper, or that they have got better methods of consuming it, or to what would you say is the increasing use of the small coal due?—The change is due in a great measure to the fact that it is cheaper.

10207. Economical reasons?—Yes, it is more economical. You see, the chemical properties of the small coal are practically the same as the chemical properties of the large coal, the only difference being that the small coal contains more foreign matter than the large coal, and if you use a coal that cakes or coheres in the process of combustion you get almost the same result out of that in an ordinary tramp steamer as you would in the use of large coal. That has been my personal experience in another capacity in which I am eng ged, namely, that of a steamship manager.

10208. Is the tramp steamer forced in working as much as, shall we say, the mail steamer?—Oh, dear no.

10209. Would that help?—That would help considerably, I have no doubt. In my own experience as an owner of tramp steamers, if I want to force a large boat an extra knot per hour, it increases the consumption of bunker coal very considerably.

10210. Yes, but it would make the difficulty of using a larger proportion of small coal greater, would it not?—It might a little, but not materially, I think.

10211. Is the price of small coal now such that it would pay to bring the small out of the pit under another system?—In my opinion, yes.

10212. The main use of Monmouthshire coal is for steam-raising purposes, as I understand, principally for locomotive and steam bunkers, is it not?—Yes.

10213. Is Newport the natural port?—Yes.

10214. What are the exports from Newport?—They amount to about 40 per cent. of the total production of the county.

10215. That represents about 4,000,000 tons per annum?—That is so. Large quantities of Monmouthshire coal are also sent to Cardiff, Penarth, and Barry, likewise for shipment abroad, or for use in steamers' bunkers.

10216. Would the Glamorgan and Forest of Dean coal pass through the same route?—Very small portions of either Glamorgan coal or Forest of Dean coal are shipped at Newport.

10217. Are the coals from those two districts as good?—The principal coal from the Forest of Dean is quite dissimilar from that of Monmouthshire: it is a house coal and not a steam coal. Then the ordinary run of coal from Glamorgan is less bituminous than that of Monmouthshire.

10218. What is the distance to the port of shipment?—Do you mean from the Monmouthshire pits to Newport?

10219. Yes?—The average distance is from 18 to 20 miles, and the average railway rate from the pit to the Newport Docks is about 1s. 1½d. per ton. But the local railway company will carry the same coal to Cardiff for 3d. per ton more, and Cardiff is 12 miles further from the pit's mouth. A still greater anomaly is that the same coal can be carried from the same pit to Barry, which is 10 miles further, at an increased rate of only 3d. per ton as compared with Newport.

10220. You look upon that as a great advantage to Monmouthshire, do you?—Yes.

10221. It widens the market?—Yes.

10222. (*Mr. Brace.*) But it is a disadvantage to Newport as a port?—It is a disadvantage to Newport as a port.

10223. (*Chairman.*) Is the Monmouthshire coal fairly free from foreign matter?—The large coal is particularly so. I have had many analyses made of large coal that disclosed under 2 per cent. of ash, and it is within my knowledge that large contracts are made with foreign railways and others where a guarantee of not exceeding 4 per cent. of ash is given.

10224. Would you say that the small coal in recent years has been more largely mixed with foreign matter?—Yes, that is so in Monmouthshire.

10225. To what is that due—different seams or greater carelessness, or what?—I think it is due to the good times that the miners have been experiencing to a great extent, which makes them more careless than they were.

10226. It has nothing to do with the high price of coals, I suppose?—Partly.

10227. (*Mr. Brace.*) I suppose it is also because, as a seller of coal, you can sell coal of less good quality when times are good: customers will take coal with a little more ash in it, I suppose, without much complaint?—The position of the salesman is always very greatly relieved when he has a clean coal to deal with.

10228. (*Chairman.*) By the way, talking about clean coal, would you say that the increase of foreign matter is due to a larger quantity being left in—being put in I will call it—or a less quantity taken out?—To a larger quantity being put in, I think—I mean filled into the trams at the bottom of the workings.

10229. It is not that there has been a process of sorting it—taking out the foreign matter—which is less carefully done now?—No, the process is the same. I think, perhaps, I might say upon the question of percentage of ash in small coal, that there are two modes of shipping coal in South Wales: one mode we call "colliery screening," whereby the coal is not screened a second time, and the other mode is that we sell it as "double screened." The process of double screening takes place at the port, not at the pit, and it is screened as it passes over the shoot out of the truck into the ship's hold. "Double screening" is the technical term for it, and that is the description of double screening.

10230. It means the second screening, as I understand?—Yes.

10231. The first screening still continues at the pit, but there is a second screening at the port?—That is so.

10232. (*Sir George Armytage.*) You divide it into two classes, as it were?—Yes. Then, *à propos* of the question of foreign matter in small coal, I may say that we invariably obtain 6d. per ton more for the small coal that is screened the second time (that is, the double screening as done at the port) than we do for the small from the colliery screenings done at the pit. The reason of that is that there is a much less percentage of ash in the double screening than there is in the ordinary colliery screenings.

10233. (*Mr. Young.*) Is the second screening not much larger than the first screened coal?—No, it is the same. They both pass over screens of the same mesh, or a similar mesh, at any rate, within a ⅛th to a ¼ inch mesh.

10234. Is there not a smaller percentage of coal duff in the second screening?—Yes, much smaller. In our own particular colliery we are able to extract at the pits screens about 20 per cent. of small, and when we double screen the same coal at the ports, the average percentage of small that we are able to extract in the process of second screening is from 8 per cent. to 9 per cent.

10235. (*Chairman.*) Making 28 per cent. or 29 per cent. in total?—Yes.

10236. (*Sir George Armytage.*) Is that what you mean, or do you mean that you get 8 per cent. out of the 20 per cent? You first of all screen your coal and you get 20 per cent. of the small at the pit?—Yes.

10237. What you screen the second time is only the small that you have got from the pit?—No.

(*Mr. Brace.*) The large coal; it is the large which is sent to the seaboard which is screened again.

10238. (*Sir George Armytage.*) You get a further 8 per cent. out of that?—Yes, out of the large coal.

10239. (*Mr. J. S. Dixon.*) You get 8 per cent. out of 80 per cent., so that there would be more than 28 per cent. over all?—Yes.

10240. (*Mr. Sopwith.*) Where is that second small made; is it broken in transit or could it not be extracted?—Well, South Wales coal is of a somewhat friable description. It is the process of passing over the shoots that causes a good deal of small coal to be made.

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10241. (*Chairman.*) And the second screening gets rid of the small coal which has been caused by the handling ?—Yes.

10242. (*Mr. J. S. Dixon.*) Can you tell us the width of the bars ?—Yes. At the Alexandra Docks at Newport they vary from 1 inch to 1⅛ inch.

10243. (*Chairman.*) Is that the same as at the colliery ?—Practically the same.

10244. You say, "It is not at all unusual to see 13 per cent. to 15 per cent., and even more of ash in the small coal, which can only arise through careless filling into trams, and emphasises the necessity for extending the scientific treatment of small coal." What do the concluding words of that sentence mean ?—I mean for the washing of small coal and for the extracting therefrom of the nuts and peas, coking the residual small coal and recovering bye-products.

10245. Of course, the first thing would be to discourage the filling of dirt into it, would it not ?—Certainly.

10246. Do I gather that in your view, as an available resource, you would run the risk of having the dirt in it coming out of the pit in order to secure that the whole of the coal came out ?—Certainly I would.

10247. We shall hear something from you later about washing and cleansing, I understand ?—Yes.

10248. Is much coke made in Monmouthshire ?—I estimate that from 600,000 to 650,000 tons per annum of coke are made in Monmouthshire.

10249. Is that made entirely from the small coal ?—Entirely from the small coal, and very largely in the old-fashioned Beehive ovens, although the retort oven is coming gradually into operation. What I mean by the retort oven is the ordinary Coppée oven. There are no installations whatever in South Wales for the recovery of bye-products in coking.

10250. Not in the case of the retort ovens ?—No: with the exception of isolated instances, where in the retort ovens I think the waste gases are utilised for steam raising purposes, but the actual bye-products in the shape of tar, benzole, and ammonia are not recovered at all in South Wales.

10251. Can you account for that ? Is it thought to be of no value ?—Well, in my opinion it would be of great value. I fear we have not been sufficiently enterprising in our district yet to avail ourselves of these modern methods.

10252. Are there no modern plants put down ?—None whatever for the recovery of bye-products.

10253. There is nothing in the character or quality of the coal to account for that, is there ?—No. You will see later on I give some figures upon that point.

10254. Is the coke used locally ?—Large quantities of it are used locally, but principally for furnace purposes.

10255. Is any of it exported ?—A remarkably small percentage of Monmouthshire coke is exported. During the last two years only 20,000 tons per annum have been exported from Newport.

10256. Where did that go ? Is it known ?—It is known, but I have not the information in my head at the moment.

10257. You say the coking is mainly done in the ordinary Beehive oven ?—Yes.

10258. And there is no plant for the recovery of bye-products ?—None whatever.

10259. Is the quantity of coke produced by the Beehive oven greater, or is the value of it greater than that produced in the retort oven ?—The price of it as distinguished from value used to be a little higher than it is now.

10260. That is of the Beehive ?—Yes.

10261. That is altered, is it ?—Yes. The furnace managers are gradually commencing to recognise that the retort coke is as good for their purposes as Beehive coke.

10262. Have you had any experience which enables you to give comparative figures ?—I have.

10263. Would you give us those figures ?—The collieries with which I am associated make coke in the Beehive ovens, and our average production of coke is from 60 to 62 tons per 100 tons of coal. I have also had the same coal coked in the Simon-Carvès ovens by way of experiment, and the result was 74 tons 6 cwt. of dry coke per 100 tons of coal; and I have also had the same coal coked in the Semet-Solvay ovens, and in that case 100 tons of coal produced 76½ tons of dry coke.

10264. Would the value of those be about the same per ton ?—Practically.

10265. (*Mr. Brace.*) In addition, you would have the advantage of bye-products, would you not ?—Yes.

10266. (*Chairman.*) Is the cost of labour greater in the one case than the other ?—In which case ?

10267. The Beehive, as compared with the other ?—I have no practical experience upon that point, but at our own colliery the cost of making coke in the Beehive oven is about 1s. 9d. per ton; that is per ton of coal used.

10268. There was no difference in the method of treatment of the coal beforehand, was there; I mean one was not washed and the other unwashed, or anything of that sort ?—Oh, no. In each case the small coal was washed.

10269. Therefore the conditions of the 100 tons were the same ?—Yes.

10270. Is there any plant in Monmouthshire for what I will call "assorting" the coal into different sizes ?—Yes, that is coming now into vogue more generally than it did.

10271. It raises the selling-price of the coal ?—Yes. I estimate that nearly 40 per cent. of the collieries in Monmouthshire now have washeries and means of extracting the nuts and peas from their small coal. If you take last year's figures the average net price at the pit for colliery small was about 5s. net per ton, for pea coal about 7s. net per ton, and for nut coal about 9s. net per ton—at the pit in each case.

10272. Could you say what percentage of pea and nut coal would be obtained from the small ?—Yes; in our own case about 13 per cent. of nuts, and about 30 per cent. of peas or beans.

10273. What would you call the remainder, slack or dust ?—Yes, the balance would be about 40 per cent. to 45 per cent. of dead small for coking purposes, and the rest rubbish; the rubbish averages anywhere from 10 per cent. to 15 per cent., in accordance with the natural cleanliness of the small coal.

10274. And that comes out in the natural course of washing ?—Yes.

10275. Is the export of coal from Monmouthshire mainly to the continent ?—Are you referring to small coal or large coal ?

10276. For the moment I was thinking of the whole of it; dealing with Monmouthshire coal generally, small and large, and taking the export side of it, does it go mainly to the Continent ?—No, mainly to the Mediterranean and South America, largely also to the Continent.

10277. Do you know whether any portion of the small coal is exported to Germany ?—Yes.

10278. Do you think any of it there is used for the purpose of coking ?—A considerable portion.

10279. By the way, do you know whether any of it is made into briquettes ?—Do you mean whether any Monmouthshire coal is made into briquettes ?

10280. Yes, either here or on the Continent ?—A small portion of it would be, mixed with coal that is of a drier character.

10281. Are briquettes made in Monmouthshire ?—Briquettes are made in Monmouthshire to a small extent, but they are only made out of Glamorganshire coal, or very largely made out of Glamorganshire coal.

10282. Is that process done at the port of shipment or at the colliery ?—At the port of shipment. All the briquette works in South Wales are at the port of shipment and not at the collieries.

10283. (*Mr. J. S. Dixon.*) Do they use the double-screened small, or the colliery small ?—Both.

10284. (*Chairman.*) Do you think the coal-tax has affected the export ?—I do.

10285. You have some reasons for thinking that, no doubt ?—I have, particularly in regard to the export of

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Mr. John Procter Eeles.

24 Feb. 1903.

small coal from Monmouthshire to Germany for the purpose of coking. This particular form of export has fallen off very considerably since the imposition of the coal-tax.

10286. Does it come within the price which carries tax with it ?—Well, it depends. It depends upon the state of the market.

10287. Surely it would not be affected otherwise ?—If it is above 6s. per ton net it has to bear the export duty of 1s. per ton, but if it is 6s. per ton net or less then it is free from tax.

10288. Would you say that the price of the small coal is more than 6s. ?—At the present moment Monmouthshire small coal is over 6s.

10289. Is it much over ?—It is about 6s. 6d. to 6s. 9d., and in some cases as high as 7s.

10290. (*Mr. Bell.*) When you speak of the price, is that the colliery price to the shipper, or the shipper's price to the foreigner ?—That is the colliery owner's price to the shipper, last week.

10291. And that coal is now paying duty ?—Such of it as is exported for cargo purposes pays duty, but a portion of it is shipped for bunkers, and bunker coal, as you know, pays no duty.

10292 (*Mr. Young.*) Has it ever been less than 6s. since the tax came into force ?—No, I do not think it has. There have been isolated cases where less than 6s. has been taken.

10293. You are now getting 6s. 6d. or 6s. 9d. ?—Yes.

10294. Would the owners never think of selling it at 5s. 11d. or 5s. 11½d. ?—That is a question for the owners. I am afraid we are treading on rather dangerous ground.

10295. (*Chairman.*) You think that Monmouthshire does offer a large field for the application of plant for washing, cleaning, and so on, do you not ?—That is my opinion.

10296. Do you know anything about the cost of the process ?—For the washing and cleaning ?

10297. Yes.—About 1½d. per ton in our own case for washing.

10298. Then the prices you gave us and the percentages of peas and nuts would seem to leave an ample margin for paying the cost of cleaning it ?—Yes.

10299. Besides providing a better market ?—Yes.

10300. For some purposes, is the nut coal, when cleaned, nearly as valuable for steam-raising purposes as the larger coal ?—Undoubtedly ; from its market value it must be so. For the sake of argument, if I am selling Monmouthshire coal now at, we will say, 14s. (that is only a hypothetical price) I should be getting about 12s. for my nut coal.

10301. That is about 2s. difference ?—Yes.

10302. (*Mr. Brace.*) And what for peas ?—2s. per ton less again.

10303. (*Chairman.*) I think you have said that Monmouthshire coal generally is capable of being coked ?—Nearly the whole of it.

10304. You have made some experiments as to the result of recovery of bye-products, have you not ?—I have.

10305. Would you tell us what that is ?—In order to demonstrate beyond all doubt whether ordinary Monmouthshire steam coal really was suitable, not only for coking, but for the recovery of bye-products, I sent 712 tons to one battery, a Semet-Solvay battery in the North, which was sufficient coal to keep that particular battery at work for a full week. The result was that I got a good quality of coke. I will give you the figures : this coal yielded 76·5 per cent. of dry coke, 94½ lbs. of tar, in addition to 16 lbs. of sulphate of ammonia.

10306. Per ton ?—Per ton of dry fuel treated. I have not taken into account the percentage of waste gases.

10307. I have no doubt you made careful calculations at the time. Should we be too inquisitive if we asked ou to tell us what the financial operation was. After all, that is the real point, is it not ?—Do you mean as to this particular 712 tons ?

10308. Yes. As I understand, the point of your evidence is this : there is a large field for economy and for improving the value of the product ; you give this as a particular instance where you made the experiment, and you give us the result of the product in coke, in tar, and in sulphate of ammonia. Now, the 712 tons represented so many pounds sterling : the cost of manipulating it represented so many pounds sterling ; and the product realised so many pounds sterling. Did it show a good profit in the process ?—It would show a good profit in the process at present prices ; it would show an excellent profit.

10309. Then why is it not done. It is want of enterprise, you say ?—I think partly want of enterprise, and partly owing to the fact that I do not think it is generally known that the Monmouthshire ordinary coal appears to be suitable for recovering bye-products in a profitable quantity.

10310. Then they want some technical education in Monmouthshire, apparently ?—Yes.

10311. And you are able to tell us that it added 18d., for example, to the value of the coal per ton ?—No ; I have not worked out the figures in detail, but I have no doubt it would add more than 18d. I have refrained from working these figures out in detail, because I understand they have already been submitted to you by other witnesses.

10312. Quite so, we have had the cost of the process, but, of course, what occurred to me was that in this particular instance, possibly, you might have arrived at what the financial result of the operation was ?—No, I have not, for the simple reason that I understood you had already the information before you.

10313. (*Sir George Armytage.*) What distance had the coal to be carried to the place where it was coked ?—To North Wales—Brymbo, Wrexham.

10314. How many miles ?—About 120 miles I should think, or perhaps more, probably 130.

10315. (*Chairman.*) Then I suppose that would be sold in that district as coke, would it ?—No, in order to satisfy myself that retort coke made in these patent ovens was marketable and good, I distributed it amongst three of my own customers in the Midlands ; I sent 100 tons to one, 150 tons to another, and 100 tons to a third, all of whom were customers who were buying from me at that time coke made from the same coal in the ordinary Beehive ovens. So that, really, the evidence obtained from the reports of these customers was of some value to me at the time, and in each case they reported that the quality of coke was excellent, and that it quite suited them.

10316. (*Sir George Armytage.*) They were aware that it was made differently ?—Yes.

10317. (*Mr. Brace.*) You went into that experiment more in order to find out the value as to quality than financially ?—Both.

10318. (*Mr. Bell.*) But it was not a commercial speculation to send 712 tons to North Wales ?—No, it was not intended as a commercial speculation.

10319. (*Professor Lapworth.*) But you would suggest, as they were successful in coking in that case, that establishments might be started in South Wales ?—Yes.

10320. (*Mr. Bell.*) With regard to reasons why bye-product ovens are not more generally used, is it on account of the general ignorance throughout the collieries in Monmouthshire of the fact that bye-products can be obtained by that means ?—I should not like to say that.

10321. Or is it by reason of prejudice ?—No, I think there appears to be a general opinion that the volatile matter in ordinary Monmouthshire coal, although it is sufficient to produce an excellent coke, is not sufficient in the ordinary way to produce an excellent coke combined with a fair yield of bye-products. It is upon that point only that I think—perhaps it may be a little presumptuous of me to call it ignorance—exists.

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10322. (*Chairman.*) Where is the nearest technical school or college?—There is a technical school at Cardiff and another at Bristol.

10323. Probably they are in possession of all the facts with regard to the character of the coal and what it will produce?—I am sure they would have that information.

10324. (*Mr. Brace.*) They do not seem to have made a very special point of the study of coking and bye-products in those schools?—I do not know, I am not sufficiently posted to be able to say.

10325. (*Mr. Bell.*) When you sent the 712 tons to Wrexham, you were aware of and knew all about this question of recovery of bye-products?—Oh, I sent it for that purpose.

10326. For what purpose?—For the purpose of ascertaining the percentage of coke obtainable from it, and what yield this particular coal would give of tar, light oils, and sulphate of ammonia.

10327. You knew, generally, that there was a prejudice existing at that time in the minds of furnace proprietors against the use of this retort coke?—I did.

10328. And one of your objects would probably be to disabuse their minds, or to assure yourself that there was no ground for this prejudice?—It was to assure myself in the first place, that there was no ground for it.

10329. At the place where you sent this coke they had ovens producing coke already?—Yes, they were the Semet-Solvay bye-product ovens.

10330. (*Sir Lindsay Wood.*) But they were not producing coke from that particular class of coal?—No, they were not in the habit of coking that particular class of coal.

10331. (*Mr. Brace.*) The coke ovens you were in the habit of using at your own collieries were the Beehive ovens?—Yes.

10332. (*Mr. Bell.*) At any rate you have established the fact apparently that this Monmouthshire small coal is a very excellent coal for using in retort ovens for the recovery of bye-products?—I have established that fact on a practical basis by having sent forward so large a quantity to be dealt with; I mean to say the experiment was not a laboratory experiment at all; it was an absolutely practical experiment, and to the best of my knowledge and belief it is the only case where Monmouthshire coal has been so practically treated.

10333. (*Chairman.*) Is the production of the collieries in Monmouthshire large enough to keep one of these large retort ovens going?—You mean any particular colliery. Oh, yes, some of them.

10334. That is an important point, is it not? The alternative to that is that you put it somewhere within easy reach of several collieries?—Yes.

10335. Then you say, "The ordinary run of Monmouthshire coal by the process of washing will yield about 13 per cent. of nut coal passing over a one-inch mesh screen, 30 per cent. of pea coal passing over a five-sixteenths-inch mesh, leaving 45 per cent. of fine small for coking purposes, and about 12 per cent. refuse more or less, according to the natural cleanliness of the raw small coal. The average price realised during 1902 for ordinary Monmouthshire colliery small was about 5s. a ton net at pit, for pea coal about 7s., and for nut coal about 9s.; whilst the average price for coke was about 14s. 8d. at the ovens." Are those the figures that you give?—Those are the figures.

10336. Then you say, "The cost of washing is about 1½d." That is per ton, is it not?—Per ton.

10337. "And the cost of coal used for coking in Beehive ovens is about 1s. 9d. per ton." That is plus the 1½d., is it?—Yes.

10338. You do not state what the average of the small coal works out at. You give us the value of it as being 5s. per ton net at the pit, and then you give us certain prices for different portions of it, including the coke, but you do not tell us what the average per ton works out at?—No, I have not done that.

10339. It would be a very simple calculation from the figures you have given?—Yes, it would be a very simple calculation.

Mr. John Procter Eeles. 24 Feb. 1903.

10340. I see you touch upon the point as to which I asked a question, and you say, "Several arguments have been advanced against individual colliery proprietors embarking in the enterprise of erecting bye-product ovens in connection with single collieries, and there is much weight in these contentions. First, there must be continuous working of the plant; secondly, a regular and unfailing supply of small coal; thirdly, it is essential to use a coal which will combine the double property of producing good coke, and also a fair average yield of bye-products." But those conditions, I thought, you had satisfied yourself existed?—I have satisfied myself that they exist in a particular instance, but I should not like to say that they exist right throughout the Monmouthshire coal-field.

10341. When you say a particular instance, is that typical of a large zone or area?—Yes.

10342. (*Mr. Young.*) Is there much difference in the analysis of that coal and coal in other parts of Monmouthshire?—Analysis in which regard—in regard to the percentage of volatile matters?

10343. Yes.—The ordinary run of Monmouthshire steam coal contains from 20 per cent. to 22 per cent of volatile matter; that is the coal that is worked from the lower measures. Then in much smaller quantities by process of little levels, the upper of the household measures in Monmouthshire are also worked, and the volatile matter in those cases is much as 34 per cent. sometimes.

10344. (*Chairman.*) Do they mix?—No, but I suggest that in the process of making coke in bye-product ovens it would be desirable to mix a certain proportion of the coal from these upper measures with the drier coal from the lower measures.

10345. Is it known whether the drier coal from the lower measures will coke, although not producing so much bye-products?—Oh, yes.

10346. With regard to the conditions to which you have referred, would you say that they are complied with generally in Monmouthshire?—Scarcely.

10347. Why?—What are the objections or difficulties?—Well, there is always the labour question with us; then the climatic conditions largely govern the regular working of the pits.

10348. But the labour question is no worse in that particular district of Monmouthshire than in other parts of the country, is it?—I am afraid in the County of Monmouthshire it is.

10349. Is there more holiday-making, or what?—No, there is a more restless spirit amongst the men.
(*Mr. Brace.*) Not at your pits, surely.

10350. (*Chairman.*) Are there any other conditions?—It is almost practically impossible to bank coal in South Wales, and stocking small coal would probably result in its losing its chemical properties.

10351. When you say it is almost impossible to bank small coal, do you mean that there would be resistance against your accumulating a stock; or is it with regard to weather, or space, or what?—Space principally.

10352. (*Mr. Brace.*) What do you mean by climatic conditions?—I think the question of weather in the working of South Wales collieries is a rather more important element than it is in collieries in other parts of the country. The prevailing winds in South Wales are from the south-west, and when it blows very hard it is almost impossible for the big steamers which are coming round from continental ports in ballast, and which are blown out like balloons, to get round to land. The consequence is that we are waiting very frequently three or four days for a steamer to arrive, and we have our collieries stopped accordingly.

10353. (*Chairman.*) That has nothing to do with the labour question?—No. I was answering Mr. Brace's question with regard to climatic conditions.

10354. I understand that, only you said climatic conditions largely govern the regular working of the pits. Then you say that banking coal in South Wales is practically prohibitive. Does that mean by reason of its cost, or because of the want of space?—Both.

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Mr. John Procter Eeles.

24 Feb. 1903.

10355. (*Mr. Brace.*) If you explain to his lordship that the pits are very often on the sides of mountains, where it is impossible to get space to place coal, it will be better understood, perhaps ?—Yes, that is so.

10356. (*Chairman.*) Does the coal deteriorate by keeping ?—The small coal deteriorates more rapidly by keeping than the large coal does.

10357. Is it subject to greater deterioration than the coal in other districts, for instance Yorkshire ?—I could not answer that question.

10358. But you think its virtues would perish ?—I do.

10359. Has there been any attempt to form independent companies with capital to erect a large plant ?—There has been no successful attempt to my knowledge.

10360. That probably would be best done by several collieries uniting, would it not ?—Either by several collieries uniting, or by the formation of independent companies who could draw their supply of small coal from the collieries in a given district.

10361. Yes, a system of co-operation among the collieries, say by the pooling of the coal and dividing the result ?—That would greatly assist.

10362. It would ensure a supply, would it not ?—It would, in my opinion.

10363. Now, coming to briquettes, you say this is an important industry in South Wales, will you give us the details with regard to it ?—Yes.

The exports of patent fuel have been published within the last few days. They are, for 1902, as follows :—

	Tons.
Cardiff	382,290
Swansea	478,323
Port Talbot	69,962
Newport	69,596
	1,000,171

The total exports from the United Kingdom during 1902 amounted to 1,050,256 tons, of which South Wales contributed 1,000,171 tons. It will therefore be seen that the export trade of briquettes from the United Kingdom, apart from South Wales, is a negligible quantity.

These figures are compiled from the Cardiff Chamber of Commerce Returns published to its members in January.

The figures for South Wales ports practically represent the total production, because the home consumption of patent fuel is very small indeed.

For purposes of classification it will be convenient to group Newport, Cardiff, and Port Talbot in one class and Swansea in another class. Taking this view it will be seen that the production of Swansea is practically within 10 per cent. of that of the other ports put together, although the Swansea district represents a much smaller coal-producing area.

The bulk of the patent fuel manufactured at Newport is from Glamorganshire coal, that at Cardiff is also almost entirely from Rhondda Valley coal, also that at Port Talbot or from coal equivalent thereto, whilst the fuel made at Swansea is from local coal which is of a more anthracitic nature. The average percentage of pitch required to make Cardiff patent fuel is 8 to 8½ per cent., whilst for the Swansea fuel about 10 per cent. pitch is required owing to the anthracitic character of the small coal used. Makers of best Cardiff patent fuel claim for their product that it is about equal to ordinary Admiralty steam coal, both as to calorific power and freedom from smoke. It stows in less space than large coal, is convenient to handle, is immune from spontaneous combustion, and is not liable to deterioration or loss of virtue in hot climates. An instance is on record where, in the course of excavations, 20 to 30 56 lb. blocks of Cardiff fuel were come across which had laid buried for 35 years. These were analysed, and found to contain moisture, 1·2 per cent. ; ash, 7·55 per cent. ; and calories, 78·10. This instance came to light within the last 18 months. It may be of interest to state that the total export of patent fuel in January, 1903, is only about 5½ per cent. less than in January, 1902, despite the fact that pitch has risen in value from about 30s. per ton to 60s. per ton in 18 months.

As I am dealing principally with Monmouthshire coal, I may here remark that although there is a patent fuel manufactory at Newport the fuel made there is chiefly from Glamorganshire coal.

Immense quantities of South Wales small coal are exported annually to France, Italy, and elsewhere, for the purpose of making briquettes; one firm alone with whom I have business relations export no less than 600,000 tons per annum to one country for patent fuel purposes. It cannot be disguised that there ought to be an opening in this district for the manufacture of increasing quantities of briquettes.

10364. Newport stands at the bottom of that list in South Wales ?—Yes.

10365. Is that its relative proportion ?—No, it is not its relative proportion.

10366. Still, there is a great deal more coal shipped at Cardiff than at Newport, for instance ?—Yes, a very great deal more.

10367. (*Mr. Brace.*) Not more than at Swansea ?—No. There is very much less coal shipped at Swansea for instance, than there is at Cardiff, but a greater quantity of patent fuel is made in the port of Swansea, than is made in the port of Cardiff.

10368. (*Chairman.*) Is that due to accident, or is it due to the quality of the coal being more suitable ?—I think it is due more largely to accident ; it just so happens that patent fuel works have been established in Swansea and have not been established to the same extent in Cardiff.

10369. But is it not the fact that either at Swansea or Cardiff there are works that make only the very best briquettes—I mean made of the very best materials ?—Yes.

10370. Is that at Swansea or Cardiff, or both ?—I think it would be invidious to draw distinctions between the two ports, because the same coal is available at Swansea as is available at Cardiff.

10371. Then the answer is at both ?—Both, I should say.

10372. Can you answer this question ; first, is the briquette business increasing ?—No, it is remaining, I should say, about stationary.

10373. Are they prosperous concerns which are carrying on business ?—Many of them have been, I believe, exceedingly so.

10374. Is the business largest in the better class of briquette or in the inferior class ?—Oh, the business is much the largest in the best description of briquette.

10375. And would the growth, if any, in the business be in the better class ?—In my opinion, yes.

10376. Therefore the deduction to be made from that is that up to the present, at all events, the briquette business has only been successful where the very best material is used ?—It has been more successful where the best material has been used.

10377. But would you not put it higher than that—because I gather from what you say that the extension of business is in the better class of briquette ?—Yes, I think I could almost do so.

10378. Therefore, with regard to the question of utilising inferior coal, that does not point to much progress by means of briquettes ?—Not in South Wales.

10379. Would you say that that might be accounted for by the fact that there is such an abundance of good material ?—Yes, to some extent.

10380. For what purpose is the small coal which is now utilised—I am speaking now of the best quality—used, if it is not used for the purpose of briquettes ?—It is used for steamers' bunkers.

10381. Does that mean that it can be used alone, without admixture with larger coal, for such purpose ?—In some cases it can be, especially in the case of steamers which have forced draught arrangements.

10382. Does that require any specially-constructed furnace ?—No.

10383. (*Mr. Bell.*) Have you any idea of the percentage of small which is produced in Monmouthshire, and which is shipped as small coal and used and sold as small ? I think you said there were 40 per cent. of the collieries now making coke ?—No, 40 per cent. having

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washeries and making nuts and beans. Some of these collieries do not make coke.

10384. So that it seems that between the number of collieries which are manipulating their small coal in that way, and the production of coke, which you say is about half a million tons, the percentage of small coal shipped as small must be gradually less and less?—I should say that the total production of small coal in the county of Monmouthshire would be from 2,500,000 to 3,000,000 tons per annum.

10385. Yes, that is what I have taken it as—2½ million tons?—Yes.

10386. (*Chairman.*) Shipped?—No, that is produced entirely. Of that proportion—this is purely a rough estimate, you will understand—I should say about 1,000,000 tons would be used for making coke, and the balance is distributed generally for all kinds of purposes. What proportion of it is actually shipped as small coal I could not tell you without looking it up.

10387. But you give the figure of 1,000,000 tons shipped as briquettes, do you not?—No; I am now dealing purely with Monmouthshire coal.

10388. (*Mr. Bell.*) Do you consider that the price of coke regulates the price of small coal in Monmouthshire?—Well, it would be a governing factor, but I should not say that it absolutely regulates it.

10389. What is your principal market for coke?—The principal market for coke outside of that which is consumed at the large iron works in the district is in the Midlands—in the Staffordshire district, the Birmingham district.

10390. That entails a very heavy railway rate?—Yes, that entails a railway rate of from 4s. 9d. to 5s. per ton, according to the furnaces that it is intended for.

10391. Then if this manufacture of coke under improved conditions went on it would lead to a much larger use of small coal, and therefore there would be less small coal available for other purposes?—Undoubtedly.

10392. The small coal is, you say, being more and more appreciated for bunker purposes?—Yes.

10393. Have you any opinion as to whether it has arrived at its true relative value, or is it worth more to people who know how to use it?—That is a very difficult question to answer.

10394. At present the price of small coal seems to be about 50 per cent. of the price of large, in round figures?—Yes.

10395. That percentage is very much more than it was a few years ago?—Yes, very much more—much more in my short experience of South Wales.

10396. And it might even increase?—I think the tendency will be for the relative value of small coal as compared with large to increase rather than to decrease.

10397. (*Mr. Young.*) What is the cause of that?—Its more extended uses now as compared with previously. The extension of electrical operations throughout the country has greatly increased the demand for small coal.

10398. (*Chairman.*) I see you speak with, I was going to say, some contempt of the "Toy briquette factories for making fuel for household purposes"?—Yes, my Lord, I am afraid I do.

10399. Is it not the fact that some very competent authorities have expressed the opinion that the present briquette is quite wrong in its proportions if it is to be used successfully for household purposes?—I believe that opinion has been expressed.

10400. That it would be better if it were thinner and rounder?—Yes. Some 12 or 15 years ago experiments were made with the little ovoids in South Wales, but I think they were not a success.

10401. Were they made from the good coal?—Yes, made from the good coal, and for bunker purposes, but I think it was found that they would not stand the pressure, and they all crumbled away.

10402. But the best anthracite steam coal is not the best for household purposes, is it?—Oh, no.

10403. Apparently there is no trade in the export of briquettes except from South Wales?—That is so.

10404. And that, I take it, is largely due to the fact that briquettes are made of a better class of material?—The bulk of the briquettes for steam-raising purposes are made from the small coal of the Admiralty large coal, combined with a small percentage of what we call the drier description of coals from the Aberdare Valley.

10405. Do you know whether it keeps its quality better in the form of briquettes?—I believe it keeps its quality in the form of briquettes very well.

10406. Better than in the large coal?—I should not like to say that.

10407. But would you not say so? Do you not say that it stows in less space, is immune from spontaneous combustion, and is not liable to deterioration and loss of virtue in hot climates?—Yes.

10408. Would you say that the large coal was not liable to that?—Perhaps I have not expressed myself very clearly in regard to liability to deterioration or loss. Of course there must be some deterioration by exposure to hot climates.

10409. I thought it was generally accepted that the admixture of binding material tended to preserve the valuable qualities of the coal in the form of a briquette to a greater extent than they are preserved in the form of the coal as it comes out of the pit?—I think that is what the briquette makers claim, but what amount of truth there is in that I do not know.

10410. I suppose you do not do business in briquettes?—I do not.

10411. Is there much South Wales small coal exported to France and Italy?—Enormous quantities.

10412. Do you mean for the making of briquettes?—Principally.

10413. What are the ports it goes to?—Mainly to Genoa, Savona, Brindisi, Venice.

10414. That is Italy mainly?—Yes.

10415. And France?—In France, to St. Nazaire, Havre, Bordeaux, and also to Marseilles.

10416. Then you think that there ought to be an opening in the Monmouthshire district for the manufacture of increasing quantities of briquettes?—I do.

10417. Do you claim for the Monmouthshire coal that it is as good as the Admiralty quality? It is hardly as good, is it?—Hardly.

10418. (*Sir Lindsay Wood.*) With all these extended uses of the small coal is there not an inducement to the colliery owners to bring larger quantities to the surface?—Yes.

10419. Are any steps being taken in that direction?—Yes.

10420. Then the waste of small coal in future you think will be less than it is now—that is underground?—I do.

10421. Will that be brought about by arrangement with the men or is there any difficulty in coming to arrangements in that way?—The difficulties hitherto have been entirely on the part of the masters, not on the part of the men. The men would be only too glad to be paid for raising small coal as well as large, I should say. It appears to me that at the present moment the men are doing something for nothing by being paid for raising large coal only.

10422. That would depend entirely upon what they were paid, would it not?—Of course they are supposed to be paid a higher wage for raising large coal than they would be if they raised only through and through.

10423. It would do away with the inducement to get a larger percentage of large if they were paid on all filled by them?—Yes, it would.

10424. Do you think there is much increase in fitting up of plant upon tramp steamers for using small coal, that is to say, with forced draught?—No; many of the tramp steamers can now use ordinary Welsh small coal without any special arrangement of their furnaces.

10425. Without forced draught?—Yes.

10426. But that is rather new. I have always understood that the Welsh small was rather difficult to burn in a boiler fire?—Not a semi-bituminous coal.

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Mr. John Procter Eeles.

24 Feb. 1903.

10427. You have said there is a large quantity of small coal shipped to France for the purpose of coking ?—More particularly to Germany.

10428. To Belgium and Germany ?—To Belgium and Germany. Hamburg takes large quantities of Monmouthshire small coal, and I know for a fact that that is coked there in bye-product ovens.

10429. And that has to bear the cost of 8s. 6d. per ton, you say ?—That bears a cost of 8s. 6d. per ton, at least; and that leads me to think that if the enterprising German can afford to pay 8s. 6d. per ton for the coal laid down at his ovens, over and above the price at which we are able to produce it at the pit's mouth, there must be a large profit in it.

10430. The Germans seem to be able to make a profit, even having to pay that additional cost ?—Yes.

10431. (*Mr. Bell.*) How do you make it 8s. 6d. ?—It is from the pit's mouth to Hamburg. The railway rate, including tipping, weighing, and all expenses from the pit's mouth to put it free on board at Newport, is 1s. 9d. per ton; the rate of freight from Newport to Hamburg is an average of 5s.; coal tax 1s., wharfage 2d., and then I assume that the cost of transport from the ship to the works near Hamburg would amount to another 1s. per ton. That brings the price up to more than 8s. 6d. from the pit's mouth.

10432. (*Sir Lindsay Wood*) Do you think the imposition of the 1s. per ton for the coal tax is causing more small to be left underground and rather stopping the demand for that class of small ?—I could not express an opinion upon that.

10433. (*Chairman.*) Do you know the proportion of small coal exported from South Wales or from Monmouthshire particularly, which comes within the scope of the coal tax ?—I have not the figures in my possession, bnt they are easily obtainable.

10434. (*Sir Lindsay Wood.*) I take it that the difference in the value of the small made into coke by the bye-product ovens really amounts, by your figures, to 14 tons more coke, 94lbs. of tar, and 16lbs. of sulphate of ammonia? —Yes, together with 2½ gallons of light oil, in the particular case I refer to.

10435. The value of that is to pay the additional interest on the capital for the plant ?—Yes.

10436. And the labour ?—It would do so.

10437. And that, you think, would be sufficient to cover the increased cost?—From estimates I have made I think on present values a very handsome profit would be made by Monmouthshire coal being treated in that manner.

10438. There is one paragraph in your statement which I do not quite understand. You say that the cost of washing is about 1½d. per ton ?—Yes.

10439. And that the cost of the coal used for coking in Beehive ovens is about 1s. 9d. per ton ?—That is the cost of labour for the coal.

10440. (*Chairman.*) Of course that is calculated upon the coal, and not upon the coke ?—Yes, calculated upon the coal.

10441. It is a little less than 2s. per ton for washing and coking ?—Yes.

10442. (*Sir Lindsay Wood.*) I take it that the question whether briquettes are made in large quantities or not really depends upon how you can otherwise dispose of the coal ?—I scarcely follow your question.

10443. I mean that if you can sell the coal by itself and make as much profit out of it without it being made into briquettes, you would not make it into briquettes ?—Well, in no case in South Wales are briquettes made by colliery proprietors. They are all separate companies that make briquettes, and they buy the small coal in the open market from the various colliery proprietors of the district.

10444. (*Chairman.*) Plus the small coal, as I understand, which is made at the port by the second screening ?—Quite so.

10445. (*Sir Lindsay Wood.*) Then it would depend upon the relative price that the briquette makers could buy the coal for and what they could sell the briquettes for ?—Yes, and also the same conditions will govern as to whether they can compete with ordinary large coal, which, of course, they do now.

10446. Do you know of any works that are now being stopped on account of the high price of coal ?—No, but I know of works that are now being stopped on account of the high price of pitch. One particular works at Cardiff I understand has been idle for over three months on account of the very high cost of pitch. Until 18 months ago some of the local briquettes factories had contracts for their pitch at 28s. to 30s. per ton, but now the price of pitch is from 60s. to 65s. per ton.

10447. (*Chairman.*) Is the pitch imported or made at home ?—It is made at home.

10448. Mainly ?—Yes.

10449. Is none imported from Hamburg ?—I do not think so.

10450. (*Mr. J. S. Dixon.*) I think it is the opposite way, is it not; pitch is exported in large quantities ?—Yes, it is exported in large quantities.

10451. (*Sir Lindsay Wood.*) Is any heat used with the coal in the making of briquettes ? Is the coal heated at all ?—I cannot describe to you the practical details of making briquettes.

10452. (*Mr. Sopwith.*) What percentage of pitch do they generally use on an average ?—In the case of briquettes made in Cardiff the average percentage of pitch is from 8 to 8½ per cent. In the case of briquettes made in the Swansea district the average percentage of pitch is about 10 per cent. The general quality of the coal from the Swansea district is of a drier or less bituminous description than that of Cardiff, and consequently, I presume, it requires a little more pitch to make it cohere.

10453. Have they been successful with the anthracite coal in briquette making in Swansea ?—I assume they have been, from the fact that they export so large a quantity every year.

10454. It is actually anthracite that they export ?—No, not what we know in the trade as anthracite.

10455. (*Chairman.*) Could you say what put the price of pitch up to the extent you have spoken of ?—Yes; it is very largely owing to the extension of electric tramways in this country where they use wooden roads, and I am told they must have pitch at any price for it.

10456. It is not owing to lessened production, but to increased consumption ?—It is both; a lessened production also applies, I believe, owing to the fact that the gas works are now using water gas and oil in the manufacture of gas to a larger extent than they did previously.

10457. Does that mean that per 1,000,000 cubic feet less coal is used ?—Yes.

10458. (*Mr. Bell.*) I should like to ask you whether you would care to put into figures the amount of tons of small coal produced in Monmouthshire that is shipped as small. You start with 2½ million tons as the total production, probably ?—Yes.

10459. And you suggest that there is 1,000,000 tons made into coke ?—Yes.

10460. If 40 per cent. of the collieries are manipulating this small coal in the manner which you have described, would you say that they are manipulating 1,000,000 tons of small ?—I should think so.

10461. That would leave some half a million tons to be sold as small ?—The quantity will be more than that, but it is the people at these collieries that are using their washeries, who are also making the coke. So that you must add another 1,000,000 tons.

10462. Probably it would be safer to say that about 1,000,000 tons is sold as small ?—Exported or sold.

10463. Well, sold and shipped; used as small and sold as small ?—I should say so.

10464. (*Professor Lapworth.*) Do you say that you do not know whether the Technical Schools in the Mining Section of the University College at Cardiff or Bristol have entered into the questions either of the coking of coal or the profitable yield of bye-products ?—I do not know whether they have.

10465. Do you consider that it would be of general benefit to the mining community of Monmouthshire and other parts of South Wales if those who were responsible

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for the mining classes of the University Colleges at Cardiff and Bristol were to enter into this practical question amongst others, of the yield of bye-products, and either test these matters in their laboratories or collect the information from those who, like yourself, have made experiments, and that they should form centres which should keep the mining community, not only the students, instructed with regard to what is going on ?—Yes; I think the answer to that question is obvious; anything that would improve the general education of the people would be of immense benefit to the community.

10466. (*Mr. Young.*) I think you said that you think the quantity of small coal exported has been affected by the tax ?—It has, principally to the near Continental ports in Belgium, Holland, France, and Germany.

10467. You think that if the tax had not been imposed a larger quantity would have been sent to Germany and Belgium where, as you have mentioned, it cost 8s. 8d. to send it ?—Yes, I should imagine so. We have had to find other outlets for our output in the meantime.

10468. Do you know what quantity was sent last year, compared with the year 1900 ?—To what ports ?

10469. To those in Germany and Belgium, where you said it cost 8s. 8d. to send it ?—No, I have not the exact figures at my disposal at the moment.

10470. (*Mr. J. S. Dixon.*) You tell us that there is a large quantity of small coal left behind in South Wales ?—Yes.

10471. If that was all produced would not that be a great inducement to the coalowners to utilise it by coking and putting down bye product plants ?—I am sure it would.

10472. Then are not the greater uses and demands that you have spoken of for that class of coal, for steamship purposes and others, an inducement to bring out a larger quantity of it ?—Undoubtedly.

10473. Is there much small coal used in South Wales for local purposes for raising steam ?—Not, of course, nearly so large a proportion in South Wales as in other parts of the country, because South Wales, speaking generally, is not a manufacturing district.

10474. You gave us some information with regard to briquettes, and you said they are chiefly made at Swansea. Is that owing to the fact that the dry character of the coal there is more suitable than in other parts of South Wales ?—To some extent.

10475. (*Dr. Le Neve Foster.*) Did I understand you correctly to say that there were no bye-product plants in South Wales, or did you say no bye-product plants in Monmouthshire ?—No bye-product plants in South Wales whatever.

10476. That is to say the whole of South Wales, including Monmouthshire ?—Yes.

10477. You have spoken about the washing. What is the description of the principal washing plants which are used ?—The ordinary gravitation plant, in Monmouthshire.

10478. What do you mean by the ordinary gravitation plant—the feldspar washers ?—Yes, the ordinary feldspar washers.

10479. Then you say that the extension of electrical plants has induced an increased demand for small coal. What is the connection between the two ?—The connection is that in the boilers in connection with the electrical plant they use very largely small coal, and nut and pea coal.

Mr. John Procter Edles.
24 Feb. 1903.

10480. Does not that mean then that the users of electrical plants are more up to date with regard to burning coal than other people ?—I do not know that it follows, but it would almost bear that construction.

10481. I have tried to find the connection. Then you did not seem to speak favourably with regard to the ovoid briquettes for bunker purposes ?—No. I think it was found that the large quantities that were required to be stored in the ship's bunkers were so great that the mechanical pressure caused them to crush and fall away to atoms.

10482. Have you had any experience with regard to those briquettes for domestic purposes ?—No.

10483. You do not know anything about their use in that respect ?—No.

10484. Do you think there is any reason why small ovoids perforated, for instance, should not be used for domestic purposes conveniently ?—I should say it would be a convenient form of making domestic fuel.

10485. I understood you to say that one effect of the coal tax had been to prevent a certain amount of small coal being sent away from this country ?—To certain competitive countries, yes.

10486. To Germany ?—Yes.

10487. May not that be an advantage to this country in making the manufacturer or the colliery proprietor of this country find out some means of utilising the small coal and getting a profit which would otherwise go to the German ?—That has been the burthen of my evidence to-day.

10488. In that regard the Coal Tax has been an advantage to us ?—It certainly has been a disadvantage to the coal trade generally. I am not prepared to speak otherwise as to what advantage it may have been to the country at large.

10489. It may have been the means of a profit remaining in this country instead of going to Germans ?—I could not say.

10490. (*Mr. J. S. Dixon.*) You gave the cost of washing coal at 1½d. per ton. Does that include anything more than wages ?—No, that is labour only.

10491. It does not include capital charges ?—No, nor establishment charges.

10492. (*Sir George Armytage.*) I understand you to say that generally what you mean is that if the small coal was made into coke, and so forth, at or about the pit's mouth in Monmouthshire, there would be a very great economy as compared with what is now done in selling it abroad ?—Yes.

10493. That is really the main point you want to impress upon us ?—That is so. That is, we should conserve the national wealth of the country at home instead of sending our raw material abroad and allowing the foreigner to exploit it to his own advantage.

10494. (*Chairman.*) That is all in favour of taxing it a little more, is it not ?—I see you have no doubt from your calculations that the German pays the tax ?—Yes, the German pays the tax.

Professor F. W. BURSTALL, M.A., M.I.C.E., M.I.M.E., called, and Examined.

PRODUCER GAS.

ITS PRODUCTION AND TRANSMISSION.

Professor F. W. Burstall, M.A., M.I.C.E., M.I.M.E.
24 Feb. 1903.

10495. I shall deal only with the utilisation of small coal, leaving out of account the larger coal, which may be raised from the pit, and transmitted to a distance in the usual manner.

(1.) In nearly all collieries there is produced a large quantity of small inferior coal, called slack, and in certain cases the coal is of such a nature as not to be marketable.

(2.) The systems of producing gas from coal may be sub-divided into four main heads:—

1. By heating in a retort—lighting gas.
2. By blowing air through the fuel, but not in sufficient quantities to complete combustion—Siemen's gas.
3. By blowing steam into incandescent coal—water gas.
4. By passing both air and steam through the fuel—producer gas.

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Professor F. W. Burstall, M.A., M.I.C.E., M.I.M.E.

24 Feb. 1903.

(3.) From the point of view of supplying the fuel for the purpose of both heating and power production, the last method is the only practicable one. All the former are intermittent in their operation, with the exception of the Siemens, which produces a gas suitable only for metallurgical purposes. The ideal producer must be capable of supplying a clean, uniform gas continuously from fuel of an inferior quality, and must be free from the troubles due to caking, which is always found when burning bituminous coal. For this reason we need not consider the Dowson producer, which can only use a non-caking coal or coke. An important point in connection with the production of gas from coal is the recovery of the residuals. It is a well-known fact that if the temperature at which the gas is formed is not too high, the producer gas will contain such a percentage of ammonia as to render the recovery of the residuals an important matter.

(4.) Taking the best known form—that of Dr. Mond—it may clear matters to describe the formation of gas from common bituminous coal or slack. The coal is filled into a dome-shaped vessel ; it is here heated, and some of the gas is formed. This gas passes through the higher portion, and part of the tar is destroyed. The temperature of combustion is kept very low, by means of the large quantity of steam blown in with the air (2½ tons of steam, per ton of slack). The object of blowing in the steam is to keep the temperature of combustion lower, and also it contributes to the formation of gas of regular composition. The hot gas on leaving the producer passes into a regenerator, where some of its heat is given to the incoming air and steam ; from thence the gas passes to the washer, where any unburnt carbon is removed. If ammonia recovery is desirable, the gas is led through an acid tower, where it meets a solution of ammonia sulphate, together with a small proportion of free acid, the ammonia combining to form sulphate of ammonia ; the gas then passes through the cooling tower and the air tower, and is now ready for use either in gas engines or for heating purposes. The composition of producer gas made by this method is :—

1. Carbon Monoxide	11%
2. Hydrogen	29%
3. Marsh Gas	2%
4. Carbon Dioxide	16%
5. Nitrogen	42%

(5.) The calorific value is about 140 British thermal units per cubic foot—that is, about a quarter of the calorific value of lighting gas. The amount of gas produced per ton of slack varies, but is about 140,000 cubic feet per ton. The heating power of the gas, as compared with the original heating power of the coal, is about 84 per cent., but it must be borne in mind that, whether for heating or power purposes, a fuel can be used much more economically in the gaseous form than in the solid.

(6.) The value of the ammonia sulphate recovered per ton of slack is about 4s. 6d. which represents about three-quarters of the cost price of the slack if the situation of generation is favourable. The ammonia recovery is, however, only financially possible when the plant is of a large size. The ideal case for the manufacture of producer gas is to place the installation as near as possible to the pit mouth, thus saving the carriage. The small and inferior coal could be gasified, while the larger and better quality of coal could be shipped to other districts. In general, however, we may assume that, except for the raising of coal, there will not exist in the neighbourhood of the pit any considerable demand either for power or gas. It, therefore, becomes imperative either to turn the gas into electrical energy on the spot and to transmit to those points where a demand for energy exists, or to transmit the gas itself in pipes.

(7.) In all questions connected with the distribution of power, we have to consider the irregularities of demand during the day. The ratio of the average demand to the maximum capacity is termed the load factor, a quantity which varies from about 11 per cent. in the case of electric lighting, to about 25 per cent. for combined electric lighting, power, and tramways. As the capital sunk in mains, producers, etc., is independent of the fluctuation of the demand, it is clear that if by any means the load factor can be increased, the cost of energy could be diminished. An ideal method of effecting this would be to produce energy at a regular rate, and store the surplus during the times of light loads. At the present moment this is too costly, both for producer gas and electricity ; the only real solution is to tap some new source where energy is required.

By far the largest consumption of coal is that used for heating, whether for manufacturing purposes or the warming of buildings ; for this reason it is desirable, if possible, to transmit the producer gas itself into those neighbourhoods where a demand exists, not only for lighting and power, but for heating ; the obvious difficulty is, of course, the size of the mains. To transmit gas of such a low heating value, in such a manner as to be able to sell gas at prices which would compete with that of raw coal, it is necessary to use pressures in the gas mains very largely in excess of those used in lighting gas mains ; the question of leakage need not be a serious one if a properly-designed joint be employed. Considerable experience on leakage from mains under pressure has been obtained from experiments on the air mains in Paris, where the pressure is about 100lbs. per square inch, and the length more than 20 miles. It was found that a leakage of less than ·4 per cent. per mile could be obtained, and this, with a network comprising a comparatively large number of branches and valves to customers. I see no reason to doubt the fact that in long mains, with comparatively few branches and valves, the leakage could be reduced to less than one-tenth per cent. per mile. In the case of transmission, the only unavoidable loss is that due to friction, and this loss is extremely small if the velocities do not exceed about 50ft. per second. The very high efficiencies which could be obtained in transmitting air or gas do not seem to have received that attention which they deserve until recently.

(8.) I have calculated the power transmitted by a 48-inch main under different conditions of pressure and velocity ; it has been assumed that one brake horse power per hour can be obtained from 70 cubic feet of producer gas per hour ; the power actually required for compressing the gas is also given.

It will be noticed that for pressures up to about four atmospheres, that is, 44lbs. per square inch gauge pressures, and a moderate velocity of 30 feet per second, it is possible to obtain efficiencies above 87 per cent. with a transmission of eighty miles, the power transmitted by the main at full load being 75,000 h.p. ; at lower loads, where the velocity is smaller, the efficiencies will be higher as the loss in the main varies as the square of the velocity. These efficiencies are considerably better than those obtained from electrical transmission. The question of the capital cost of the gas mains as against those of the electric mains cannot be stated in general terms, as much depends on the particular locality, but there is no reason to consider that the cost will be greater than for a given amount of power transmitted electrically.

(9.) These figures show that gas transmission has an extremely high efficiency if the velocities can be kept down. I estimate that of the total gas produced, 60 per cent. would be used for heating. It is well known that the fluctuations in the demand for gas for heating purposes are much smaller than those for lighting and power. It is fair to assume, as the ratio of mean to maximum for this portion of the output would be 50 per cent., that the load factor of the whole plant would be 30 per cent. for the heating gas, and the remaining 40 per cent. would be used in gas-driven central stations producing 3-phase currents at pressures from 5,000 to 15,000 volts, according to the size of the districts which they had to cover. At these same stations the gas would be distributed at low pressures, so that no serious difficulty from leakage need be anticipated ; the 3-phase current could be converted at suitable sub-stations into continuous current at 440 volts for use on trams and for lighting ; part of the electric currents could be distributed for power purposes as 3-phase at pressures of 500 volts. Taking the load factor for this part of the system as 25 per cent., we have a load factor of 8 per cent. on the gas produced for electric purposes, making a total load factor for the gas plant of 38 per cent.

(10.) The use of large gas engines for the generation of electricity is now only in its infancy, but it may be taken as quite certain that within a few years we shall see engines of from 4,000 to 5,000 h.p. capable of running with such regularity as to allow the alternators to be run in parallel. The economy of the large gas engine is undoubted.

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Taking the best steam engine as consuming 1½lbs. of coal per indicated h.p. hour, the coal being 15s. per ton, the cost is pence for a h.p. hour is ·126d. In the gas engine, if the ammonia be recovered, the cost will be ·008d., and if the ammonia is left in the gas, it will be ·032d. per h.p. hour.

(11.) The capital cost of gas driven and steam driven stations is rather in favour of the steam plant, but as the size increases the gas station will become cheaper per unit than the steam plant. Producer gas is particularly suitable for all manufacturing purposes where a temperature not exceeding 1,100° Centigrade is required; higher temperatures could of course be obtained by the aid of a regenerator. Amongst other purposes it may be employed for manufacturing of steel, melting of brass, brickmaking, in pottery manufacture, enamelling, and in fact for any purpose where at present coal is employed. One of the minor advantages, but one which is important to the health of the inhabitants who live in the neighbourhood of manufacturing centres, is the total absence of smoke, as the producer being closed cannot produce smoke, and during the combustion, whether in a gas engine or in a furnace, it is impossible to produce incomplete combustion. As the gas contains as much as 11 per cent. of the highly poisonous carbon monoxide, it may be considered as objectionable to risk gas under pressure, where a leak might prove fatal even in the open; as a matter of fact, ordinary lighting gas frequently contains a greater proportion of carbon monoxide, and this is frequently transmitted without the slightest trouble arising, although the joints are nowhere gas-tight. Modern engineering is certainly capable of producing a gas main in which the leakage should not be such as to give rise to any serious difficulties due to the poisonous nature of the gas. The most important argument to be urged in favour of the extended use of producer gas is that it can be manufactured as well from the large quantities of inferior coal, which up to now have not been worked because they could not command a sale, and also because the valuable sulphate of ammonia is recovered and can be used as a fertiliser. The amount of ammonia which could be obtained from the coal raised in this country would be far more than sufficient to enable us to dispense with the importation of any kind of manure, while the use of gaseous fuel would very probably save from 30 to 50 per cent. of the total coal consumed in this country.

Professor W. Burstall, M.A., M.I.C.E., M.I.M.E.
24 Feb. 1903.

TABLE giving the length of transmission, H.P. transmitted, I.H.P. required for compressing, and the efficiency for a gas transmission through a main 4 feet diameter, 70 cubic feet of gas per brake horse-power hour. Mechanical efficiency of compressor = ·8, compression curve taken as P.V. 1·3 = Constant.

Initial Pressure Absolute.		Length of transmission in Miles.			Horse-power of Gas delivered by Mains.			I.H.P. required to compress the Gas.			Efficiency of Transmission V = 20, 30 or 40.
Lbs. □″	Atmospheres.	Initial Velocity in feet per sec. V. V = 20.	V = 30.	V = 40.	V = 20.	V = 30.	V = 40.	V = 20.	V = 30.	V = 40.	
15	1·02	7·66	3·4	1·92	13,130	19,200	26,260	30	44	60	99·7
15·4	1·05	18·6	8·2	4·65	13,550	19,800	27,100	65	95	130	99·5
16·2	1·1	34·5	15·3	8·6	14,150	20,700	28,300	116	171	233	99·2
17·6	1·2	61	27·1	15·2	15,500	22,600	31,000	273	399	545	98·2
22·0	1·5	133	59	33	19,300	28,350	38,750	780	1,120	1,535	96·2
29·4	2	150	66	37	28,850	37,820	51,600	1,780	2,610	3,565	93·4
44·1	3	178	79	44	38,750	56,700	77,500	4,500	6,596	9,000	89·6
58·8	4	182	83	46	51,650	75,500	103,200	7,780	11,400	15,550	87·0
73·5	5	191	85	48	64,600	94,600	129,100	11,550	16,910	23,100	84·9
88·2	6	194	86	48·5	77,500	113,500	155,000	15,890	23,290	31,875	83·0
102·9	7	196	87	48·9	90,300	132,000	180,700	20,630	34,560	41,370	81·5

10495* (*Chairman.*) You have come to give evidence with regard to producer gas, its production and transmission, I understand. Those are the main questions, are they not?—That is so.

10496. Will you tell us about the utilisation of small coal?—The principal thing that I wish to emphasise is the importance of obtaining a producer irrespective of the particular make, Mond or Duff, or any other one, which will utilise the caking coal and the small coal, and in fact which will gasify anything which has carbon in it. For that purpose the temperature of the producer must be kept low, otherwise there will be a destruction of the ammonia, and it cannot be too strongly impressed that it is an essential feature of gaseous fuel that the ammonia be recovered at some stage or other, otherwise the efficiency of the producer will not be nearly so high from a financial point of view. I will put it in this way: the value of the sulphate of ammonia recovered from one ton of coal is about 4s. 6d. That reduces the actual price of the gas to being the coal equivalent of 1s. 6d. per ton, taking the slack at 6s. per ton delivered at the producer. That is the reason why the Dowson producer, or any of the hard coal producers, are not nearly so satisfactory from the point of view of any large scale as the Mond or the Duff or bituminous producers.

10497. Does that mean because the hard coal does not produce the value in ammonia?—No; the hard coal can be made to produce the value in ammonia, but, as they are generally arranged now, the quantity of steam used in the Dowson plant is not nearly so great, and the resulting temperature in the producer is much higher. Then I would also make rather a strong feature of the fact that sulphate of ammonia is a bye-product whose value is not likely to sink when the amount of it is increased. Sulphate of ammonia is one of the best fertilisers known, and as, moreover, the nitrate fields are if anything diminishing their output, the only alternative is sulphate of ammonia, and it would be a matter of very great importance to our agriculturists if the price of sulphate of ammonia could be dropped by any means from its present price of about £12 per ton to say £6 per ton; it would mean an immense help to agriculturists at home. At present sulphate of ammonia when burnt under a boiler is, of course, being entirely destroyed, and therefore as an asset we are neglecting altogether the ammonia in the coal. Now I should like to say a little about the transmission and its efficiencies.

10498. I wanted to ask you a question which, perhaps, would come better when you come to the question of transmission, because you deal under the head of trans-

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Professor F. W. Burstall, M.A., M.I C.E., M.I.M.E.

24 Feb. 1903.

mission both with the question of transmission in the form of gas and in the form of electric energy, do you not ?—No, I have not given the figures for electric energy.

10499. But you give them for gas ?—Yes.

10500. Of course what you have said about the agriculturist if he could have the price of ammonia reduced from £12 to £6 would affect what you have said in your calculations, that ammonia represents 4s. 6d. at present ? Yes, of course it would.

10501. You say that the ammonia recovery is only financially possible when the plant is of large size. What do you mean by "large" ?—About 4,000 h.p.—producing sufficient gas for 4,000 h.p.

10502. That is the minimum size for economical work, is it ?—That is the minimum size that will repay the capital sunk in the acid recovery towers.

10503. I gather that your view is that the ideal case for the manufacture of producer gas is to place the installation as near as possible to the pit mouth ?—That is so.

10504. That is as to the question of saving carriage of the coal, is it not ?—Yes, that the inferior coal shall be raised from the pit and dropped into the producers without having to load up into wagons or anything of that sort.

10505. When you say near the pit mouth, of course that does not preclude having it somewhere where it could obtain the produce from several pits ?—No; by that I rather meant that it should not be at such a distance that it would require transport into railway wagons.

10506. Then if that is the case you must have it very near the pit's mouth, must you not ? It would either have to be transported into railway wagons, or some other wagons, because you do not contemplate that it could be poured from the screen into the dome of the producer without loading again ?—That is what I should prefer.

10507. But do you think that the product of a particular colliery would be sufficient ?—No, probably not; it would have to be a group of collieries on a particular field, and of course arrangements would have to be made for the mechanical transport of the coal in the cheapest possible manner.

10508. You contemplate that producer gas, as I understand, could be conveyed either in the form of gas or could be converted on the spot into electrical energy and transmitted in that form ?—Yes.

10509. Have you any views as to which is the cheaper plan ?—That must depend upon the form of the locality. If the locality is one where any considerable amount of manufacturing is done, it will pay to transmit the gas in pipes, because the manufacturer requires far more fuel for heating purposes than he does for power purposes. Therefore the electrical energy is not so useful to him as the gas would be.

10510. Is there any limit, or what would you say would be the maximum distance which you could economically transmit gas in pipes to reach the centre of population such as you describe ?—I think about 80 miles in one transmission would be the limit, that is to say, 80 miles with only one set of pumping. If you choose to take two or three sets of pumping, I think probably about 300 miles is the limit.

10511. That would be large enough for any distance in England ?—Yes; it is perfectly feasible to supply London with the whole of the coal that it requires from the Derbyshire and Staffordshire fields.

10512. (*Mr. Bell.*) You mean all the gas ?—In the form of gas.

10513. (*Chairman.*) I see in your table of composition of the producer gas made by Dr. Mond's method you put nitrogen very high—42 per cent. of the whole ?—Yes.

10514. Is that available for producer gas ?—It is of no value at all from a heating point of view.

10515. Is it possible to take the nitrogen out ?—No, not at present.

10516. Does 42 per cent. represent its proportion of volume ?—Yes, by volume.

10517. It is of no use, as I understand, for the purposes of power ?—Neither the carbon dioxide nor the nitrogen is of any service whatever.

10518. Therefore if they could be taken out it would enormously increase the facility of transmission ?—Yes, if they could be taken out the case is infinitely stronger than it is at present.

10519. Has there been any attempt made to get them out ?—Attempts have been made to get out carbon dioxide, but not the nitrogen.

10520. I thought there had been some attempt made to get it out in America. Would you now make clear to us what you mean by the pumping. Taking first your figure of 80 miles, I understood you to say that that could be done with one pumping ?—That could be done with one pumping, that is to say, the gas would be led from the producer into an air compresser where the pressure would be raised from that of atmosphere to the required pressure, which, at 80 miles, would be about 45lbs. per square inch gauge pressure. That I call the pumping or the compressing, which requires, of course, a certain amount of energy in order to pump the gas up to the compresser, the whole of that energy being expended in the friction in the main.

10521. What size of main do you contemplate in a case like that ?—I have taken 48 in. as being about the largest that would be desirable for one main.

10522. And in the case of the second and the third stage, are we to understand that your suggestion is that at the end of 80 miles, or something short of that, a second installation or compression would take up the gas and forward it again ?—Yes, that is so.

10523. And again a third stage, if need be ?—Yes.

10524. Is there any difference in cost in the first, second, and third stages ?—No, they would all be precisely similar—the same plants in each case.

10525. (*Mr. Sopwith.*) What is the limit with regard to the 300 miles ?—It must be limited.

10526. I suppose you could carry it out to any extent otherwise, might you not ?—You see each stage involves, roughly speaking, about a loss of 13 per cent. of the whole. Now it is clear that if you keep on taking away 13 per cent. of the original whole you will soon come down to a point where the amount of gas has been nearly all taken up for compression or pumping.

10527. (*Chairman.*) Will you just amplify that a little ? With regard to the 13 per cent. loss which you speak of, do you mean loss in the sense that it is consumption for the purpose of carrying forward ?—Yes.

10528. You do not mean it as a loss in the sense of leakage ?—No, not in the sense of leakage at all.

10529. Is there much loss in that sense ?—That is a matter on which we have only got the experience of the Paris air mains to guide us. There the loss is about .4 per cent. per mile on the ring main of 20 miles in length, but the pressure there is 100 lbs. per square inch above atmosphere, and the network is constructed in the streets in not a very good manner. There is reason to suppose that the loss by leakage would be about one tenth of 1 per cent. per mile; that is the maximum amount.

10530. That is assuming that the joints are made tight ?—That is assuming a mechanically made joint.

10531. Is there any difficulty with regard to the joint itself, do you think ?—None whatever; I have seen joints that have kept very high pressure indeed on them for unlimited times without showing any leak whatever.

10532. You say that in the questions connected with the distribution of power we have to consider the irregularities of the demand during the day. Would you deal with that point ? You say in your statement that the ratio of the average demand to the maximum capacity is termed the load factor ?—To illustrate that I might take one of the London Electric Supply Companies; it is the same whether you take gas or electricity. Of course it is clear that the maximum demand in the case of electricity for lighting comes on in the evening, and lasts for four or five hours, but the plant which supplies the current must be there whether it is running or not, and provision must be made not for the time of average demand, but for the time of maximum demand; and by the load factor is meant the amount of the average throughout the day to the maximum, which is supplied during a certain period

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of the day, the point being to get at some figure which will represent the ratio of the plant provided at the station to the demand made by the consumer.

10533. But in such a case would you prefer to have five towns of 300,000 inhabitants rather than one town of a million and a half inhabitants?—Their demands would all come at the same time, so that it does not affect things at all.

10534. That would depend upon their occupation to a certain extent?—Yes, but for the most part as regards the power and light, there is not a great deal of difference between any one manufacturing town and any other. Of course London is quite exceptional.

10535. The economical point being where you get nearest to the constant load?—That is so.

10536. You say that it is not possible to produce energy at a regular rate and to store the surplus?—It is not financially possible on anything but a very small scale indeed. The cost of gasholders for storing the gas would be so great as to preclude the possibility of storing any enormous quantities, and the storage battery is much too costly to store the electrical energy on anything but a small scale.

10537. You say the only real solution is to tap some new source where energy is required, that is to say, to find fresh customers?—Yes, or offer to supply to some customer for something which at present you are not offering; that is to say you have your electric light and your power and what you require to do is to provide him with his heating as well, which is a much better and more regular source of revenue.

10538. Or to apply power to some purpose to which it has not hitherto been applied?—Yes.

10539. (*Mr. Sopwith.*) I take it that there is no economy to be effected by having duplicated producers so as to have one working during the time of the minimum load, and to have the two combined for the maximum load?—Well, the stand-by loss, that is to say the loss which is going on when the producer is not producing any useful gas is so extremely small that in current practice the whole of the producers are generally kept alight that is to say, a little fire is kept in them.

10540. You can regulate the supply?—You can regulate the supply, and you can blow a producer up in a very short time indeed.

10541. That would apply to very intermittent supplies?—Yes.

10542. (*Chairman.*) That does not apply to electricity, does it?—No, electricity as produced from steam plants of course requires time in order to get the pressure up in the boilers. You cannot get a boiler under full steam as quickly as you can get a producer under its full output of gas.

10543. What is the period of time which would be occupied in getting a producer gas plant into its full power?—Supposing that it was alight to begin with—not standing cold?

10544. Yes, let us take the best case for it; the maximum capacity being two, the load at a particular moment being one; how long would it take to turn on the full load?—Not over three or four minutes.

10545. Then that means that as regards the producer I imagine there must be more than one—what shall I call it—pipe or operation going on at one time, if you are going to produce these enormous quantities?—Oh yes, the maximum convenient size for a producer is one capable of gasifying about 50 tons of coal per day or about two tons per hour; so that in the producer station there would have to be a very large number of producers, perhaps 30 or 40, all in fire at once.

10546. Yes, but supposing half of them were out, how long would that take?—That would take some hours in order to heat them up; to get them up from cold would take several hours.

10547. Are they started by gas?—No, not generally; they are started in the same way that a boiler is started, by lighting a fire at the base and then allowing them to burn up.

10548. I should have thought if you provide your customers with gas for the purpose of heating you might use it for your own purpose?—I should think it would probably be better to light them by gas, but it has not been done so far.

10549. You say that by far the largest consumption of coal is that used for heating. Does that include manufacturing?—Yes.

10550. That includes blast furnaces; you call that heating?—This producer gas, as far as I know, or any gaseous fuel, is out of the question for blast furnaces. I mean for all sorts of heating—steel making, metal rolling, manufacturing, heating of buildings, fires, and every sort of domestic purpose.

10551. (*Mr. Sopwith.*) For firing boilers?—Yes.

10552. (*Chairman.*) In fact you divide it into three—heating, lighting, and power?—Heating, light, and power.

10553. You say heating is by far the largest. Do you mean it is double?—Yes; if a gas station were producing gas I take it that 60 per cent. of the total output of the station would be taken up for heating purposes and 40 per cent. for power and light. Those are the maxima.

10554. Are you able to divide the power and light?—Well, it is rather difficult for a given locality; you see so much depends upon whether the trams are worked on it and whether the manufactories around the district are those taking large constant sources of supply or small and intermittent; so that it is very difficult to give a definite figure for any particular locality.

10555. You say that in the case of transmission the only unavoidable loss is that due to friction?—Yes.

10556. But I think you have already told us that practically the whole cost of transmission is due to friction?—Yes, the whole cost of transmission is due to friction.

10557. And that the cost is much smaller if the velocities are low?—Yes.

10558. That means large pipes and slow progress?—That is so.

10559. What proportion of London would your 4ft. pipe supply, and how many 4ft. pipes would you want?—To supply London for all purposes—in other words to do away with any coal at all coming into London?

10560. Yes?—I am afraid I should not like to answer off-hand, but a great number.

10561. 44 lbs. per square inch and a velocity of 30ft. per second you put as the maximum economy?—That is about the most convenient one, taking into account the capital cost of the main and the efficiency of transmission; that seems to be about the best case.

10562. In fact the cost of power for increasing the pressure, you put it, is greater than the interest upon the capital outlay of the larger pipe?—That is so.

10563. But the capital outlay would be considerable for a 48in. main, would it not?—Yes, of course it is very considerable indeed.

10564. Do you disregard levels?—Yes, they would have no importance; they would not affect one at all.

10565. You would follow the outline of the country?—Yes.

10566. But underground?—Preferably overground, if one were allowed to do so.

10567. But you would not be allowed to?—I take it that would depend upon the Parliamentary powers that were granted.

10568. The frost would have no effect, would it?—No effect whatever.

10569. There would be no water in it?—No, no water. You would of course provide traps at the bottom of any syphon, in order to get rid of any possibilities of tar. They would always be put in.

10570. But most of the tar you try to get out before, do you not?—Yes, nearly all the tar is taken out in the fans.

10571. You speak of "efficiencies," which is rather more than "economies," but I gather that in your view the conversion of coal into gas at the pit mouth and transmission in the form of gas would be more efficient,

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Professor F. W. Burstall, M.A., M.I.C.E., M.I.M.E.

24 Feb. 1903.

and therefore more economical, all things considered, and the purposes to which it could be applied being considered, than by converting it into electrical energy ?—Yes, most emphatically, at the pit mouth.

10572. And your view would be not to transmit energy from the pit mouth, but to transmit producer gas and to convert such portion of it as was wanted for the purposes of energy into energy at different points ?—Yes, that is so.

10573. May I put one further question upon that: When we come to running all our railways by electric traction your view would apparently be, not cables for the transmission of electric energy over great distances, but gas pipes and stations at intervals ?—That is so. Of course the actual driving of the train would be done by electrical cables, and there would be cables running between the stations.

10574. Yes, but the source of power would be gas pipes ?—Yes.

10575. But the main point with regard to that is that in your view the purposes to which gas can be applied cover so much larger a sphere than those to which energy only can be applied ?—Yes.

10576. And, as you have told us, the reason is that more than 60 per cent. of the whole is required for heating purposes ?—Yes.

10577. You speak of three-phase currents at pressures from 5,000 to 15,000 volts according to the size of the district they have to cover. These you would make at generating stations supplied with gas ?—Yes.

10578. Is that the most economical form of transmission at these high voltages for the distance that you require to transmit it in that form?—Well, I have taken it over a very wide limit so as to cover very many cases. I take it that in the case of a large town like London you would not be allowed to put your gas sub-stations down in the central area; the vibration, etc., would put you out of court. Therefore you would have to use 15,000 volts in the case of London. In the case of a smaller town, 5,000 volts would be quite a reasonable voltage to work to for covering the sub-stations.

10579. With regard to using gas for the purposes of power, do you contemplate gas engines ?—Yes; no steam boilers, all gas engines.

10580. Do you really think we shall see gas engines of 4,000 or 5,000 h.p. ?—Yes, very shortly.

10581. There is nothing of that kind in this country at present, is there ?—No, there is nothing at the present moment. There are quite a number of 1,200 to 1,500 h.p. engines on the Continent.

10582. But 5,000 h.p. would represent a very large concentration at a particular point, would it not ?—Do you mean in one particular station ?

10583. Yes ?—No, I should call it a small station.

10584. But I gather that if you only wanted 5,000 h.p. you would not use a 5,000 h.p. engine ?—No.

10585. Therefore it means one of a set ?—It means one of a set.

10586. And probably not less than 20,000 as a minimum ?—About 20,000 to 25,000 would be the power of the gas engine-driven stations.

10587. Which you can economically use 5,000 h.p. at ?—Yes; I do not say that I should put 4,000 to 5,000 h.p., but it will be possible to obtain those engines.

10588. You put the best steam engine, taking coal at 15s. per ton. Of course that is high if you are dealing with it at the pit ?—Yes, but of course this is not dealing with it at the pit.

10589. Therefore you are comparing in this case the gas produced at the pit conveyed and converted into energy by means of a gas engine at a point with coal carried in the railway trucks, we will say, and converted into steam at a point ?—That is so.

10590. And you put the difference as being ·008 for the gas engine and ·126 for the steam engine, do you not ?—That is if the ammonia be recovered from the gas.

10591. But it would be recovered from the gas, would it not, if gas were used for this purpose in this form ?—If it was done on a sufficiently large scale, yes.

10592. Yes; but it would not pay you to do that otherwise, if you were going to carry it for a distance where coal was going to cost 15s. ?—No; but, of course, gas engines are being put in in London now, and the producers are being put in with them, without any attempt to recover ammonia. In that case, of course, the gas costs are, roughly speaking, four to one, that is to say, the gas engine costs about one-quarter of the steam plant in London for small sizes.

10593. And if the ammonia is recovered it reduces the cost to what ?—It reduces the cost to about one-third of that again, that is about one-twelfth.

10594. (*Mr. Sopwith.*) That is on the basis of 4s. and 6s. ?—That is on the basis of 6s. per ton for the slack and 4s. 6d. per ton for the ammonia in a ton of slack.

10595. (*Chairman.*) You believe that the gas would be available, and could be used with advantage for many manufacturing purposes ?—Yes, for any manufacturing purposes where heat is required.

10596. Why do you say it is particularly suitable for all manufacturing purposes where a temperature not exceeding 1,100° Centigrade is required ?—That is because the quantity of inert gases, nitrogen, and carbon dioxide so reduce the temperature of combustion that it will not give a higher temperature than 1,100° Centigrade.

10597. But that would be sufficient for steel-making, melting of brass, brick-making, pottery manufacture, enamelling, and so on ?—You have to use a regenerator for steel-melting.

10598. Then practically there is nothing in the way of the introduction of this, so far as I understand, except the necessary Parliamentary powers to enable you to carry your pipes through someone else's property ?—That is so—nothing.

10599. And the ability to get customers to use it ?—Yes.

10600. In making your calculation of relative costs of power, the figures for which you have given us, do you take into account the cost of transmission ?—No, in neither case. This is simply an indicated horse-power at the engine, quite irrespective of transmission.

10601. (*Mr. Young.*) About seven-tenths of that would be lost in 300 miles. Would not that be so ?—Yes, it would be very nearly that in 300 miles.

10602. (*Chairman.*) That would increase its cost ?—Yes, in proportion. I give 300 miles, because that is the greatest length at which gas transmission is at present contemplated.

10603. Then you give us an interesting table, showing the mechanical efficiency, and so on. So far as you know, is there any movement in the direction of what you have been giving us in this interesting evidence ?—Yes, the South Staffordshire Mond Gas Company have Parliamentary powers to distribute producer gas over a certain section of South Staffordshire, and a great deal of that plant is made, and the pipes are being actually laid in the roads.

10604. In what part of South Staffordshire are they at work laying pipes ?—I could not say exactly what parts, because I have not been over there; but I am told that they are starting to lay their pipes.

10605. And that is a system of producer gas which would apply in the cases you have given ?—Yes. Of course, it is a much smaller area than I have contemplated, and therefore they are only using a pressure of 7 lbs. above atmosphere.

10606. Of course that lessens the cost of transmission ?—Oh, quite so.

10607. Is this gas at work anywhere much except at Mond's place, or the industry with which he is connected ?—It is mainly being used in chemical works, because of the fact that there they want to reduce their cost to a minimum. There is a large gas plant at Allbright and Wilson's making phosphorus; there is a large producer gas plant at the Solvay Company in America. These are all about 12,000 to 15,000 h.p. There is a large plant at the Castner Kellner.

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10608. (*Sir George Armytage.*) In your proof you say, "In general we may assume that except for the raising of coal there will not exist in the neighbourhood of the pit any considerable demand either for power or gas." Why should the coal be used for the raising of the coal? Why should not the coal be raised by the power from the gas?—It would be; but, of course, only quite a small percentage of the total coal of the pit would be used for the winding, hauling, lighting, and pumping.

10609. As I understand, one great point which you make is that by this manufacture of gas you will get rid of smoke?—That is so.

10610. And there will be no smoke whatever?—It is impossible to get any smoke.

10611. But if you were to keep the chimney going for the raising of the coal you would still have the smoke?—But I should not; I should do all the raising of the coal by means of gas engines driving three-phase plant. I should have no steam plants at all.

10612. Then you look forward to the day when these gas producers will be at the pit-mouth, and when there will be no smoke, and when power will be transmitted as required throughout manufacturing towns, and for lighting in all parts?—That is so.

10613. Have you made any comparison with regard to the proportion of economy in money that there would be by this process as against coal to-day in its raw state?—I have not made any calculations of that, because that is such a large question that it would mean a very serious amount of work to do; but in general terms it may be stated that there is a very considerable saving indeed over our existing state of affairs, taking everything into account.

10614. You say towards the end of your statement that you would probably save from 30 per cent. to 50 per cent. of the total coal consumed in the country?—Yes.

10615. That is in quantity, I suppose?—In quantity.

10616. (*Chairman.*) Or you would make the same coal do double the work?—Yes.

10617. (*Sir George Armytage.*) In mentioning the size of this plant you say it would be a plant which would yield 4,000 h.p. of gas to be profitable, and that your plant ought to be sufficient for yielding 4,000 h.p. in gas engines. Is not that so?—That is to get the greatest economy possible.

10618. Can you tell us what quantity of coal would be required per day for that to be produced?—I would rather not make any calculation at the present moment. I could only give it to you very roughly.

10619. Could you tell us roughly? I mean to say, would it be the production of one colliery or of many collieries?—Oh, a very little quantity; 4,000 h.p. is a very small amount; it would mean about 50 tons per day, roughly.

10620. Not more than that?—No—a very small amount.

10621. Then from your point of view there is no reason why a plant of this sort should not be put down at every colliery?—If it is not too far away from a manufacturing town.

10622. That is to say, in order that there may be work for the gas to do?—Yes.

10623. I think you gave an answer to a question put by the Chairman with regard to carrying the coal from the pit-mouth to the place where you wanted to put it into the oven, and with regard to whether it would be carried in railway trucks or not; but I did not quite catch your answer?—I would rather not carry it in anything but the tubs from the pit.

10624. That means to say on some mechanical traveller?—Yes, on some mechanical traveller; but, of course, my argument is not affected even if it has to travel several miles by boat, or something of that sort; it does not add greatly to the expense to barge it, but I did not contemplate, except for London, carrying the coal any considerable distance at all.

10625. (*Chairman.*) But you would carry it for London?—I am afraid that the capital cost of the main would be extreme in that case, unless that was done.

10626. (*Sir George Armytage.*) In your comparison with the steam engine you say in your statement, "Taking the best steam engine as consuming 1½ lb. of coal per indicated horse-power per hour, the coal being 15s. per ton, the cost in pence for a horse-power hour is ·126d." Is not 1½ lbs. per indicated horse-power rather high?—No, I should call it decidedly low.

10627. For a modern engine?—For the very highest class of modern engine.

10628. Have you made any estimate of the probable price that would repay putting down this plant—the rate per 1,000ft. or so forth, that the company, or whoever it was who put down these plants, would be able to charge their customers?—Yes. That depends upon the magnitude of the customer. It may be taken to vary from about 3d. per 1,000 cubic feet charged to the small customer down to possibly 1½d. per 1,000 cubic feet to the large customer.

10629. That is after paying interest upon capital and all costs of all sorts and kinds?—All costs of all kinds.

10630. How much would that work out per horse-power in the gas engine? Have you arrived at that? Is not this about a tenth of the present cost in the gas engine, taking the gas at 2s. 6d., or something of that sort?—Yes, it would be about that; it would be about a tenth of the present cost.

10631. Is it your opinion that if this was done on such a large scale as you are speaking of, you would reduce the price of sulphate about one half?—I do not anticipate that, because it is impossible to say how great the demand for sulphate would be.

10632. I see in one paragraph of your statement you say it would be unnecessary to import any further manures?—Yes, if we had this quantity; in fact, we should produce very much more ammonia than we could possibly deal with.

10633. (*Dr. Le Neve Foster.*) You say that the inferior coal at a colliery would be gasified. What percentage of ash would be allowable, and how would you define inferior coal?—Do you mean what percentage of ash could be allowed in any coal that would be used in this way?

10634. Yes?—I do not think there is any limit. I think you could use it half ash.

10635. Fifty per cent. of ash?—I think so.

10636. And therefore that would enable you to use classes of coal which are not being used at the present time?—Yes.

10637. How small a plant worked by producer gas is allowable? If you had a small factory, we will say, wanting 50 h-p. for 10 or 12 hours per day, would it be economical to put up a producer plant?—Yes, but not one of the bituminous producer plants; not one for the use of bituminous coal.

10638. You would use an anthracite producer?—Yes, up to about 250 h.p.

10639. And after that?—After that I would consider the case of the bituminous producer.

10640. How would the capital cost of the steam plant compare?—Do you mean the entire installation, or only the gas engine portion of it?

10641. No, the entire installation; you are putting up a factory, we will say, of 100 h.p., and you want to consider what a steam plant would cost and what a gas plant would cost?—It you use an anthracite producer the cost for the gas engine is considerably smaller than the best class of steam plant. If you take a steam plant which is not intended for maximum economy, then probably there is not much real difference between them. Of course, the costs of steam plants vary through very wide limits, according to whether they are designed for cheapness or for economy.

10642. That is to say, cheapness of material or economy in working?—Cheapness of material or economy in working.

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Professor F. W. Burstall, M.A., M.I.C.E., M.I.M.E.
24 Feb. 1903.

10643. I see that you speak of about 300 miles as the greatest distance to which gas transmission is proposed to be carried out. What is the greatest distance that it is in use at the present time?—That is, of course, found in the Pennsylvania natural gas field. I think it is about 120 miles, or something of that sort.

10644. With a far greater pressure of gas?—Yes; their pressures of gas are very high.

10645. (*Chairman.*) That is to say, naturally?—Yes, natural gas in the Pennsylvania field.

10646. I mean the pressure is not obtained by artificial means?—No, that is the well pressure.

10647. (*Dr. Le Neve Foster.*) I gather that you think that in the course of another 20 years a steam engine will be a thing of the past?—Except for marine purposes, I think it will.

10648. (*Mr. J. S. Dixon.*) And also boilers?—Yes; of course, boilers are not desirable things for any purpose.

10649. I see that in your statement you give the amount of gas produced per ton of slack as 140,000 cubic feet?—Of course, that is a very general term; it will vary within very wide limits.

10650. That is correct, is it?—It is approximately correct for the particular slack I mentioned; that was a fair average quality of slack.

10651. I mean it greatly exceeds the gas that is got for illuminating purposes from a ton of coal; therefore I wanted to know whether that was a correct figure?—Yes, it is a correct measured figure. Of course, in the case of lighting gas you leave 70 per cent. of your fuel behind in the shape of coke, whereas in this case the whole thing is burnt away.

10652. Then this gas is of the analysis that you have given here?—Yes. They are general figures, of course; they will vary.

10653. Further on in the same sentence in your statement you say that the power got from the gas, as compared with the original heating power of coal, is about 84 per cent. Is that 16 per cent. lost?—Yes, that is absolutely lost.

10654. How does that compare with the heat produced by the combustion of that coal in a boiler, for instance?—In a boiler you would get about 75 per cent. of the original heat of the coal appearing in the steam. Good practice is to get three-fourths of the heat turned into steam.

10655. And in the gas engines you get nearly 84 per cent.?—Oh no, I beg your pardon; this is simply the heat in the gas as compared with the heat in the coal. I have not said anything here about the amount of heat that is turned into work by the gas engine.

10656. (*Mr. Sopwith.*) In talking about the utilisation of the gas for collieries, I rather gather from what you say that gas engines must be employed. You said, in reply to a question which I put a short time ago, that it could be used for firing boilers, but I take it you assume that that would not be an economical way of dealing with it. Do you think there would be sufficient heating power to fire a range of boilers?—Yes; I have seen many boilers fired by it, but, of course, it is not an ideal arrangement. One would naturally prefer in a colliery to have gas engines generate electricity, and to do the entire work of the colliery electrically.

10657. Quite so, but you might differentiate as to the economy by saying that the use of producer gas for firing boilers would be a great improvement upon the mere use of the slack under the boilers?—Well, it is not a great improvement.

10658. (*Chairman.*) There would be no smoke, would there?—There would be no smoke, but unless you have an ammonia recovery plant it does not pay you to fire the boilers with producer gas; you can do better work by firing the boilers with raw coal.

10659. Therefore the producer gas means, in regard to collieries, the use of gas engines, practically?—Yes.

10660. May I put a question in order to make that complete; you say, "as regards collieries," but would it not apply to other sources of power?—Yes, certainly—with any source of power I should not advise the boilers to be fired by producer gas.

(*Mr. Sopwith.*) I put the question merely with regard to collieries, because that would be a source of supply, and the question was raised with regard to adapting it for collieries and using it there.

(*Chairman.*) But I understand Professor Burstall goes further than that, and says it would not be desirable to use producer gas for firing steam boilers.

(*The Witness.*) No, it would not do—in any case, unless it was of importance to utilise some existing plant.

10661. (*Sir George Armytage.*) You would rip the whole thing up and put in a gas engine; that is your point?—That is what we should do. Of course, everybody might not go as far as that.

10662. (*Chairman.*) There might be cases of this kind, where steam is almost necessary as the means of heating for the purposes required?—Yes for heating purposes.

10663. Not only for heating, but say for boiling certain things?—I will give an illustration, that at the Castner Kellner's chemical works they do fire a very large set of boilers by producer gas, because they must have steam for the purpose of evaporating their products. Therefore they prefer to gasify their coal, get the ammonia out of it, fire the boilers with it, and use the exhaust steam of the engines for drying up their chemical products. That is a case where the gas firing of boilers is a distinct advantage, but in general it would not be an advantage.

10664. (*Mr. Sopwith.*) You might be able to regulate the heat under your boilers better with producer gas?—Yes, it is an ideal firing, there is no doubt whatever.

10665. (*Chairman.*) But even in that case I gather from what you say that you do not put it forward as being an economical method of firing steam boilers?—No, not from a heat point of view.

10666. That is to say, that they could use coal and get the steam at about the same price?—Yes, that is so.

10667. With the disadvantage of the smoke?—Of course there is the smoke question.

10668. (*Mr. Sopwith.*) I think I understood you to say that the actual leakage in the mains would be of a very small amount. I take it that supposing you have a producer and you have two points where power is required to be utilised, say one is 10 miles away and the other 20 miles away, you have your large main, which practically acts as a gasometer or reservoir, where you have to keep the pressure up all the time?—Yes.

10669. If there was a leakage, that would be going on all the time, would it not?—Yes, that would be going on all the time.

10670. But that is such a small amount that it does not affect the question?—I do not think it affects the question at all. Of course if the leak was anything considerable it would mean a very serious matter, but all these gas calculations are based on the fact that the main can be made very nearly gas tight.

10671. There is no deterioration in the quality of the gas—the gas remains intact, does it not?—Absolutely intact. There is no such deterioration as takes place with lighting gas.

10672. The cost of these mains would be enormous when you got up to 4ft. would they not?—Yes, very heavy indeed.

10673. (*Mr. Bell.*) When you speak of the 140,000 cubic feet per ton of slack is that an actual experience, or is it theoretical?—That is a measured quantity on a particular slack: that is to say the producer was coupled to a meter and the coal was weighed in and the meter readings were taken. That is the actual output of gas.

10674. Then it is practical experience?—Yes.

10675. With regard to this calculation of yours about the best steam engine consuming 1½ lbs. of coal at 15s. per ton, it is ·126d., but with a gas engine, and where the ammonia is recovered, the cost would be ·008d. That is about 7 per cent., is it?—Yes.

10676. About 7 per cent. of the coal converted into this producer gas will produce the same result?—Yes, it will produce the same result, but, as the Chairman pointed out, prices are different.

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10677. Yes, but you are taking it at 15s. per ton?—At 15s. per ton for the steam coal, and 6s. for the slack coal.

10678. (*Chairman.*) I think you made it quite clear that in the one case you were taking the steam being produced at the place where it was required, and the coal having borne all the expense of transmission up to that point; in the other case you were taking the cost at which gas could be produced, assuming that you use the slack at the pit, omitting therefore in making those calculations the cost of transmission or capital outlay necessary for that?—That is so; I have neglected that.

10679. (*Sir Lindsay Wood.*) If the price of coal had been the same, there would be the difference?—It would be two and a half times; it would have been about one-sixth in that case, instead of one-twelfth.

10680. (*Sir George Armytage.*) In the latter portion of that paragraph in your statement, comparing the steam engine, you say: "In the gas engine if the ammonia be recovered the cost will be ·008d., and if the ammonia is left in the gas the cost is ·032d. per h.p. hour," one being one-fourth of the other. Is the reason for saying that, that the ammonia will pay the other three-fourths?—Yes. The ammonia will pay the other three-fourths.

10681. (*Mr. J. S. Dixon.*) At present prices?—At present prices.

10682. (*Sir Lindsay Wood.*) You have not made any calculation as to the quantity of gas that will be required to be forced through the pipes?—I have made those calculations. I did not give them because the table was already long enough, but of course it can easily be obtained as 70 cubic feet of gas per hour are required to give 1 h.p., so that to find the quantities all that is necessary is to multiply each one of these figures by 70 and that gives you the number of cubic feet which must pass through the main per hour.

10683. Then you would require a considerable quantity of gas?—Yes, enormous quantities.

10684. Have you any idea of the cost of the compressing engines required for that purpose?—Yes, very considerable indeed; they are very large engines. *Professor W. Burstall, M.A., M.I.C.E., M.I.M.E.* 24 Feb. 1903.

10685. (*Sir George Armytage.*) Would you drive those by gas?—Yes, they would be gas engines.

10686. (*Mr. J. S. Dixon.*) Like blowing engines on a blast furnace?—The same style of engine as a blowing engine on a blast furnace. I have given the size of the compressing engines. You will see they are very large indeed.

10687. (*Chairman.*) This table which is given in your statement represents the indicated horse powers required to compress the gas, does it not?—Yes, they are the indicated horse powers required to compress the gas.

10688. These are at the different pressures, are they not?—I have given the powers at the different pressures.

10689. Twenty, thirty and forty?—Yes; they are worked out by atmospheres from 1 lb. per square inch up to about 102 lbs. per square inch.

10690. Have you ever had your attention called to natural gas as existing in this country?—Yes, I have heard it exists.

10691. It has been said that Birmingham may be supplied from Sussex some day?—I do not think the quantity of natural gas existing in this country is worth considering.

10692. (*Dr. Le Neve Foster.*) But do you say so after having been down to see it?—No, I have not been down to see it, but I take it that had it been worth utilising it would have been utilised in this country long ago. I mean in comparison with the gas wells of Pennsylvania it can only be a very small quantity indeed.

10693. (*Chairman.*) But it is of much purer quality and it would go further, would it not, than producer gas?—Yes, of course. It is nearly pure methane; it would go about five or six times as far as producer gas.

10694. But you would not adopt that as your sheet anchor?—No, I certainly should not.

Mr. GEORGE BLAKE WALKER, called; and Examined.

10695. (*Chairman.*) You are Chairman and Managing Director of the Wharncliffe-Silkstone Collieries, near Barnsley?—Yes.

10696. You are a Member of the Institution of Civil Engineers, and past-president of the Midland Institute of Mining Engineers?—Yes.

10697. Are you conversant with the methods in use in the Westphalian coalfield in Germany, with regard to the cleaning of coal?—Yes.

10698. Will you tell us shortly your experience and what the result of it is? You began early in erecting washing plant, did you not?—Yes. I first visited Westphalia about 1873, and I have made repeated visits to that district since. Of course in 1873 the coalfield was only very partially developed. There was nothing like the development that has since taken place.

10699. Was there any washing plant in those days?—No washing that I remember, but it is so long ago that I do not like to say that there was not. The coalfield is exceedingly contorted, the seams are crushed by the folding of the strata, and the difficulties of keeping the coal clean and also of getting anything like the proportion of large coal that we get in this country are very great indeed.

10700. Is the proportion of small coal due to the fact that the coal is of such a nature, or is it that the broken condition has been produced by some action of the strata?—I consider it is due to the action of the strata, the crushing strain to which the seams have been subjected in the process of being folded. Of course, in England, where the seams lie comparatively level, we can work the same seam over a large area continuously, and we can adopt methods of working which are quite impossible where the seams are highly inclined and contorted. Their method differs from ours in their having to sink shafts, and then to drive what we call cross-measure drifts—horizontal drifts through rock and coal just as it comes, say at intervals of 100 metres, intersecting all the different seams which they come across, and working the majority of those seams—all those that are worth working, thick as well as thin—at the same time, and exhausting the whole seam between the different levels. When they have done that they keep on going deeper and deeper until they reach a point; perhaps the point has not been reached yet where they can go no deeper, but they are getting on to 800 and 900 yards in depth. *Mr George Blake Walker* 24 Feb. 1903.

10701. Is there any difficulty as regards depth?—Yes; they are beginning to find the heat question troublesome, and of late the peculiar disease which was first noticed in the St. Gothard tunnel—a sort of intestinal disease—has been rather prevalent in some of the deeper mines in Westphalia. A friend of mine wrote me only three or four months ago that he had about 20 per cent. of his men down with that disease, and that they were then holding a medical conference with some of the best medical men in the district as to what the real cause of the disease was, and the means to be taken to guard against it.

10702. Was it supposed to be connected with temperature?—I believe so. In the case of the St. Gothard tunnel it was first attributed to dynamite; it was supposed that the infusorial earth of the dynamite had become mixed with the air after explosion, and that this had been breathed into the system and had set up the disease; but in the case of the Westphalian mines a similar disease could not be due to that, because dynamite is not used. If it is interesting to the Commission I shall be glad to obtain in the course of a week or a fortnight the results of the medical enquiry at which they have arrived.

10703-4. It would be very interesting, I think, if we could have the results. Is not that disease now found amongst the Cornish miners in this country?—I believe there

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Mr. George Blake Walker

24 Feb. 1903.

has been a small outbreak in Cornwall, but I have only heard of it very casually; I know nothing about it.

(*Mr. Brace.*) A Blue Book has been published about it quite lately.

(*Dr. Le Neve Foster.*) It has been going on in Cornwall for years in the Dolcoath Mine, and a report has been published lately by Dr. Haldane.

(*The Witness.*) The Dolcoath Mine is a very deep mine, is it not?

(*Dr. Le Neve Foster.*) It is a deep and a warm mine.

(*Mr. Brace.*) But is there not a point with regard to the danger of getting this disease introduced into the other mines of this country? Dr. Haldane goes on to make some recommendations.

(*Dr. Le Neve Foster.*) He does.

(*Chairman.*) Does that mean that it is supposed to be contagious?

(*Dr. Le Neve Foster.*) It is contagious—through the excrement.

10705. (*Mr. Sopwith.*) Does the air in the Westphalian mine in working the deeper workings in any way go through the old workings and so carry the effluvia?—Perhaps I might say that in the last regulations of the Westphalian coalfield provision has been made for underground latrines, and the men are obliged, if they want to ease themselves, to go down to these particular places, and precautions are taken that the excrement is brought out in vessels and buried. With regard to your question about the ventilation, the ventilation is always what is called ascensional, that is to say, it rises from the bottom to the top, and as a rule I do not think the same air is used successively for the lower and then for the higher levels. But I should think the practice varies in different pits.

10706. (*Chairman.*) Would you say that the ventilation in the Westphalian mines is on a par with the ventilation of the coal mines here?—In some of the mines they have large volumes of air; on the one hand their system is a simpler one than ours; but I do not think that it is always so effectively carried into the working places as the ventilation is in ours. There are difficulties in both cases; but, on the whole, I should say theirs is a simpler system, and requires less fan-power than ours.

10707. Are their roadways and airways as large relatively?—Yes, larger, for this reason, I think: their working areas, as a rule, are not so large as ours; their main roads are large stone tunnels, generally about 12 ft. wide, and, say, 8ft. high.

10708. Do you mean built stone?—No, cut out in the rock. If the rock is soft they have to arch it, but as a rule you go along the drifts and you see simply rock-hewn tunnels intersecting the seams as they occur. These are large roads in which, of course, the air can travel very freely. Then at the different inclines the air is split off for the different groups of workings, and conducted into those workings, and it finally makes its way to the top and to the shaft by what is called the return drift, or the "*Wetter-Sohle.*"

10709. Have you, at any of your collieries, erected plant for washing small coal?—Yes; we have what is now considered a small washer.

10710. Has it been successful?—Yes, we could not have done without it; but so many improvements have been introduced that it will not compare with more modern machines.

10711. Do you mean as regards economy of production or effectiveness of work, or both?—Chiefly as regards economy of production.

10712. Do you deal with all your small coal by washing it?—Only our coking coal.

10713. But small coal is being dealt with by being washed for ordinary steam boiler purposes, is it not?—During the last two years several large plants for washing all kinds of coal have been erected in South Yorkshire at the Rothervale Collieries and at Mitchell's Main and Denaby. Those are three instances, but there are several others; there is the Staveley Iron and Coal Company, for example, and there are others in course of erection.

10714. When the small coal is washed is it separated into different sizes?—Certainly. There are two methods of doing it; the system in our case is the one which has hitherto been the usual one of separating the coal first into different sizes and then distributing it into washing boxes, where the amount of oscillation in the water is proportioned to the size of the coal. But within the last twelve months more particularly, the opposite system of washing all the coal together and then separating it has been introduced in Germany, and there seems on the part of many people to be an impression that it is an improvement.

10715. In Germany washing is applied to a much larger percentage of the total output than in this country, is it not?—It is very striking; only about 20 to 25 per cent. of the coal is what we should call large coal; the coal comes out of the pit looking very miserable, inferior stuff indeed; it looks, as we should say, all slack; it is then put over a screen having holes about 4in. in diameter, and about 20 or 25 per cent. is lump, and does not pass through that screen, but the 75 or 80 per cent. is then mechanically conveyed to the washer, is elevated to the top of the washer, and by gravitation passes downward until the different sizes of washed nuts would find their place in different hoppers, and the coking coal goes into large tanks, and from these hoppers the railway trucks are loaded through shoots, so that the coal is never touched. The saving in labour is considerable.

10716. Compared with the previous system?—Compared with attempting to sort it by hand. It is not as between the two systems, but as dealing with the screening of the coal mechanically, and dealing with it through our English methods by jigging screens, or by any other process not connected with washing.

10717. Yes, but I do not quite gather which of the two systems in your opinion is the best, both as regards effectiveness and economy, washing it before assorting it into the different sizes, or sorting it first and washing it afterwards?—I am afraid my opinion is not worth anything at present.

10718. You say the coal as it comes out of the pit in Germany looks very dirty; does it come out as regards dampness in about the same condition as from pits in this country—is it as dry?—I think that is entirely a question of particular mines, but taking it as a whole it has a more smudgy moist look.

10719. Does the cause which produces a larger proportion of small coal in Germany tend at the same time to increase the amount of foreign matter which it contains, or, I will put it, does it make it more difficult to keep them separate?—If a seam is interstratified with bands, that is to say, layers of foreign substances, it is practically impossible to pick them out in the case where the coal has been subjected to pressure; and the high inclinations of the seams and the difficulties under which the men work make it exceedingly difficult to keep the coal clean from portions of the roof or floor. For instance, you may have a seam inclined at 70°; the man stands on a platform; perhaps he is 50 yards up in the air, as it were, and he is hacking this coal down, and the coal is falling all that distance into a heap in the bottom from which it is filled. Well, the coal is soft to begin with, but it naturally gets very much more broken by the fall and the dirt is mixed with it.

10720. But the effect of the crush that you speak of, and the contortion of the seams, would operate to some extent also upon the roof and the floor, would it not?—Yes.

10721. Therefore it would tend rather to increase the foreign matter which the coal contains?—Yes, and because of that the Germans could never have made their coal industries a success without these washers.

10722. In fact, their necessities led them to what is after all a great improvement?—Certainly.

10723. Do you think we shall make progress in this country in the same direction?—We are doing so. I believe that in 20 years our leading collieries will be rather like the German collieries, although not quite so lavishly built.

10724. Is this process more economically carried out at a large colliery than at a small one?—Yes, the larger the plant and the larger the amount of coal which passes through it, the more economical it is, because practically the same staff will deal with it.

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10725. The general expenses are divided over a larger output?—Yes, and the labour bill also.

10726. You have already told us that in Germany it is usual to treat about 75 per cent. by washing. Does the washing there result in really cleaning the coal practically from foreign substance?—Yes, very perfectly.

10727. The work is done economically?—Yes.

10728. It improves the sale value of the product?—Yes. May I say in regard to the improvement in the value of the product in this country, the same value has not hitherto been attached to nut coal which is attached to it in Germany, because we have so much more of the lumps, but really there is no great advantage in having large lumps if you have to break them; and if you can get a nut which is about the right size for use, not involving any breaking, it is more serviceable fuel. The result is that instead of getting a much lower price for nuts as compared with lump coal, the German gets very nearly as much, perhaps as 9 is to 10, for his better sizes of nuts as compared with the price of his large coals. Then another point in the sale of their coal is something which is quite unknown in this country; we buy a truck of large coal, or a truck of nuts, or a truck of slack, but in Germany you frequently find that a mixed sample is ordered, that perhaps 5, or 10, or 20 per cent. of lumps are specified to be added to a sample of nuts, or there are to be two or more samples of nuts in stated proportions, so that the customer knows exactly what he will receive; he will get time after time an exactly similar sample, so that if he has mechanical stokers, or if he has any furnaces which require a particular kind of coal, he can always ensure getting the thing as precisely sized as if he was buying so much lump sugar.

10729. Is that possible in this country?—Certainly. The same result would follow the same treatment.

10730. Yes, but is it possible at present, if a man wants to get the same size and the same percentage of large and small?—I never knew it done. We are rather spoilt; our seams have been so good, and the size has been so good that we have wasted our small coal. What was called "engine slack" in the manufacturing district is coal containing a large quantity of nuts, and is sold at perhaps half the cost of production, and sold in a very dirty condition. It is not made half as much of for fuel as it might be if it was properly sorted and cleaned.

10731. But you are clearly of opinion that coal in Germany is graded more accurately than here, and that the purchaser can get more certainly any particular description or size that he may want?—Yes, and he will pay a much better price for it. That does not apply to Germany only; it applies to France and Belgium just as much.

10732. But when you say he pays a better price for it he gets a more valuable article?—Yes, but then where we perhaps sell the same stuff in this country for 6s. per ton, the German colliery would get 9s.

10733. (*Mr. Brace.*) Is that not partly due to the method of selling; in this country every colliery sells its own productions in competition with each other, whereas in Westphalia the whole of the coal produced is sold by the syndicate; all the colliery owners pool their produce and it is sold from one centre?—Yes, but if you are giving an order, you say what coal you want; you name your colliery, and you name your size; so that you know exactly what coal you are going to get and you know exactly what size you are going to get. Of course, to go into the question of the Syndicate is opening up a very large matter, but it means this, that the colliery which has the best coal and which sizes it best, and prepares it for the market in the best manner, so that there is a greater demand for that particular brand, if I may so call it, gets more orders than it can supply, with the result that the Syndicate keep raising the price of that particular coal until equilibrium is reached, that is to say, until people begin to send less orders, and go on to some of the coals which are a little less in price. It is an automatic premium upon doing the very best you can with your coal.

10734. (*Mr. J. S. Dixon.*) The colliery gets the advantage, as it were?—Most certainly.

10735. (*Mr. Young.*) Is it entirely due to grading?—If the colliery possesses a better coal to begin with, naturally it gets the advantage of that.

10736. But you say that in Germany they would get 9s. for a certain class of coal, whereas in England they would get 6s. Is that not because they take out the duff, and give a class of coal all of the size which the customer can utilise to much greater advantage than if he were buying it from us with the duff and the larger coal mixed?—You only have four sizes of coal as a rule in this country; you have large coal, large nuts, pea nuts, and slack, or "duff," as you call it. In Germany they have a great many more sizes; say, 4in., 3in., 2in., 1in., ½in., and still smaller, and then they have the fine coal. Well, it is obvious that a man who orders a 3in. nut gets a very uniform sample. If he finds it suits his particular trade he continues to order that, and he prefers to pay for the coal that suits him a higher price than he would pay for a coal of which he was uncertain.

10737. (*Chairman.*) Does the washing of the coal add much in the way of weight to it?—The coal is drained in draining hoppers and more or less efficiently. I do not think that there is more than 3 per cent. of weight added as a rule, when the coal gets into the truck.

10738. Part of which it will lose before it gets to the customer, I suppose?—Yes.

10739. You say there are two classes of unworkable coal seams, what have you in your mind?—Seams that are at present too thin to be worked with profit.

10740. Are you speaking now of Germany or of this country?—Well, generally; it applies everywhere; and seams which are so interstratified with bands as to make the cleaning too costly to make it worth your while to work them. There are plenty of thick seams in this country that are not worked simply because they are full of bands.

10741. Do you happen to know in the case of seams interstratified with bands of shale, whether the payment for getting the coal is differentiated in any way from that of the good coal?—Well, it is a matter of degree. If it is possible for the collier to pick out a sufficient quantity of the dirt.

10742. He is expected to do it?—He may be expected to do it. That is the case of seams that are worked now; but I think there are a large number of seams in every coalfield which are not worked because they may have five or six bands in them varying from ½in. to a couple of inches in thickness, and it is absolutely impossible to pick the dirt out.

10743. But apart from the question of wages, your evidence rather leads to the conclusion that with effective and complete washing apparatus, although the coal might have been mixed with this dirt, you can separate it when it gets to the surface?—Yes.

10744. It is a question of cost?—It is a question of cost because the collier would probably want to be paid for the interstratified dirt; it is immaterial to him whether the coal seam is a clean one or a dirty one; if he has to give the same labour to load it, he would probably want to be paid approximately the same price. Your haulage cost and your other costs would apply to the dirt as well as the coal, so that if there was 10 per cent. of dirt in a seam, I take it that the cost of production would be increased upon those charges something like 10 per cent.

10745. (*Mr. Brace.*) Still, seams are worked with these bands in them, and if workmen have to clean the bands they are paid an additional price, so that if you clean them on the top, although you are paid a nominal price for that seam, if the seam was clean because of your cleaning on the top, you would not pay the workman any extra for the filling?—I am speaking of seams which are not now worked. You can work some dirty seams so as to make them pay, but there are lots of seams which are not worked now because it is believed that it would not pay to work them, and which it is quite impossible for the collier to pick the dirt out of.

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Mr. George Blake Walker
24 Feb. 1903.

10746. Have you a mechanical appliance which would clean the coal on the surface from these bands ?—They must be put through the washer.

10747. But say you have a piece of coal, for instance, of *this* shape and size, and there is a patch of band, and the coal is of so much thickness ; have you a mechanical appliance that would break up that coal and pick out the coal from above and underneath and clean the band out ?—My experience is that the bands usually separate themselves from the coal ; sometimes a bit may stick to the coal, but I should think you would hardly ever, or very rarely, get a lump of coal sent out with a band right through the middle of it.

10748. If my experience may be given, we have many seams where the men get 2d. or 3d. per ton to clean those bands out because they will not separate ?—Would not the coal have to be broken up in that case ?

10749. Yes, the coal would have to be broken up. The point I was venturing to put to you was this, that instead of the collier doing that by hand-labour, have you any mechanical plants which would enable him to send the coal out as he finds it in the seam there, and by the mechanical arrangement it could be cleaned on the top. That would seem to be very much quicker and easier ?—Yes, something in the nature of a stone-breaker might be used.

10750. (*Chairman.*) But still, how would you separate it when you had broken it ? That is Mr. Brace's point, I understand ?

(*Mr. Brace.*) Yes.

(*Witness.*) I take it that the washer would do the rest.

10751. (*Chairman.*) Take two pieces of the same size, neither of which would go through the screen ; one, if you like, consists entirely of the band, and the other entirely of the coal ; but you could not separate those mechanically if they were of the same size ?—No, but the washer does it.

10752. (*Mr. Brace.*) Take a lump of coal as big as this (*pointing to box*) and, say, there is a bed of stone through it of 2in. ?—Yes.

10753. In South Wales the men get a ½d. per ton for cleaning, that is to say, that to clean that stone, and to take this piece of coal on *this* side and the piece of coal on *that* side, we get a 1d. per ton extra ; do you know of any mechanical appliance which would enable this coal be sent out in that way, so that instead of cleaning the seam by hand-labour it could be done by mechanical arrangement ?—No.

10754. (*Chairman.*) Except in the case, I understand, of some dirt which, whilst it forms the band in the coal and may preserve its general solidity, if it passes through the washer sometimes dissolves, does it not ?—In our case we have a certain amount of interstratification in the small coal, and that coal goes to a re-washing arrangement, where it is passed through a breaker, and the effect of going through the breaker is, as a rule, to detach the band from the coal, and then it is re-washed and the coal is separated from the band.

10755. But given that the band consists, let us say, of shale, and given that the shale is hard, and is not susceptible therefore to the influences of the water any more than the coal, you could not separate those by washing ?—Yes, it is a question of specific gravity ; it is not a question of softening at all.

10756. Quite so ?—Supposing the coal and the stone are mixed together loose ; the stone sinks and the coal floats, and passes over the weir.

10757. (*Mr. J. S. Dixon.*) It must be broken up in order to do that ?

(*Chairman.*) Yes. Are coal-cutting machines used much in Germany ?—Only, I think. at one or two collieries.

10758. Is that due to the causes which you have told us about, of the contortion of the seams and so on, to any extent ?—Yes, it is. The coal does not take much getting, as a rule ; it is pretty soft.

10759. Are coal-cutting machines used much in this country ?—Yes, and increasingly so.

10760. You have some experience of them, have you ?—I think I am almost a pioneer in that matter, or my father before me was. We began in 1868. We have both compressed air and electrical coal-cutters.

10761. Are coal-cutting machines making any headway ?—Certainly, very largely.

10762. Do you mean generally throughout the country, or in particular districts ?—I should say that it is in Lanarkshire in Scotland and in South Yorkshire and Derbyshire, so far as I know, that they are mostly used.

10763. There is a limit to their economical use as regards the thickness of the seams, is there not ?—Yes ; I think you may say, as a rule, they are used in seams below a yard in thickness, but I am using them in a seam 4ft. thick.

10764. Do you get quite a considerable percentage of your total output by means of coal-cutting machines now ?—At the Lidgett Colliery, of which I am a director, we get it all by machinery.

10765. With a tolerably flat inclination ?—It is a flat seam, and the seam is from 2ft. to 2ft. 3in. thick.

10766. Free from faults ?—No, but still we have large pieces between the faults which we can work.

10767. (*Mr. Brace.*) What is the minimum thickness which you think could be worked with machines profitably ?—I am afraid it depends so much on the quality of the coal, the nature of the roof, and the general cost of production when you say "profitably."

10768. (*Chairman.*) You might put the question a little differently, in this form : What is the thinnest seam you have known worked profitably ?—Fifteen inches.

10769. (*Mr. Young.*) If you took a seam, 2ft. 3in., workable by hand, what saving might there be by introducing the machine ?—I will not limit myself to 2ft. 3in. My conclusion is that on the collier's getting price there ought to be a saving of 25 per cent. If the getting price is 1s. 10d. per ton, I think there ought to be a saving of 5d., if a fair arrangement is made. It very often happens that the company do not succeed in getting an equivalent for their machinery, but if they get a fair equivalent, and the roof is good, I should think 25 per cent. ; if the roof is bad it would be less, because the collier would have to spend more time in propping.

10770. Would the collier in that case get the same wage ?—Certainly, or rather more.

10771. And you would get an extra profit in addition ?—Yes ; I think the saving ought to amount to a quarter of the getting price, but, of course, it depends on the strength of the coal, the nature of the roof, and many other conditions. But there is an important further advantage in the improved size of the coal and consequently in its value.

10772. (*Chairman.*) When you speak of the saving, do you mean after having provided for power, depreciation, interest on capital, and everything else ?—Yes. I shall be glad to send the Secretary a tabulated form in which that is worked out for seams of different thickness, if you would care to have it. (Page 96.) It was made out in 1887.

10773. Thank you. Do you think that the present use of small coal for boiler purposes is economical ?—Certainly not. Of course, that is a very large question, considering that there is every kind from the most economical down to the most wasteful in use ; but, as a rule, I think it is very much the reverse of economical.

10774. Are there any briquettes made in your part of the world ?—Very few.

10775. Is the coal not suited to the manufacture of briquettes, or is there a better market for it ?—No, there is not much of a market for it. I think myself that a great deal may be done in two ways : one is by dust firing, which obviates the smoke nuisance, and which has been a great success, notably in Berlin, where the coal is reduced to a powder as fine as baking flour.

10776. Is it blown in then ?—Yes, it is thrown on by a fan, and practically gasified. Instead of its kindling in the ordinary way, the fine particles immediately combine with the oxygen of the air, and produce an

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intense heat like a blast, very much as in the case of petroleum in Mr. Holden's locomotives. You can keep on the fire night and day, almost without any necessity for cleaning; you get no smoke, and you get almost the maximum amount of heat out of the fuel. That is a system which has not been much adopted in this country.

10777. In the case of coal of that description, it would have been washed to take out the foreign matter before being crushed, would it not?—Well, no, I do not think it follows. It may be either one or the other, but the cleaner it is the better, because otherwise you will get a lot of flue dust. If it is very dirty coal, however fine it is, your flues will eventually become filled with flue dust. Then the other matter is of course the use of producer gas, which again is an infinitely more economical way of utilising the coal than by throwing it on with a shovel.

10778. But then it is not used much in that way yet, is it?—You know the Mond and Duff Companies are now beginning to erect very large producers, for the recovery of sulphate of ammonia, from which I anticipate enormous economies will arise.

10779. Do you make any coke?—Yes.

10780. Do you use the retort ovens?—We have both; we have put up a plant of retort ovens with recovery of bye-products.

10781. Do you use the gas from those in any way for heating or other purposes?—Yes, but we only use the surplus gas at present for raising the steam that we require in the plant itself. We have no surplus.

10782. But you do not make any producer gas?—No, but I have it under contemplation.

10783. Is there any in your part of the world?—At Alfreton Colliery in Derbyshire, they have some boilers fired from producer gas.

10784. But they do not use it for gas engines for winding, and so on?—No, but I am sure that is coming. I am now getting quotations for a large gas engine for generating electricity, and electricity to be used underground for pumping and haulage of coal. I am quite certain that that is the most economical way of producing the power for all kinds of underground work, but not for winding.

10785. (*Sir George Armytage*). Why not for winding?—I ought not perhaps to have said that, because in the Dusseldorf Exhibition, there is a very excellent electrical winding engine.

10786. (*Chairman.*) But otherwise you are doubtful about electrical winding engines, I understand?—I spoke rather hastily. I think it is quite possible that they also will come in. In South Russia, the collieries of the Ekaterinovska Company have six pits, all with electrical winding engines, and also supplied with electricity from a central generating station. But when I questioned it in the first instance, with regard to winding, I was thinking that the control of those engines might not be so perfect as in the case of the steam engine, and there might be an element of risk. Still, I believe we shall see them adopted in Germany shortly. This particular engine exhibited at Dusseldorf is intended for the Zollern Colliery of the Gelsenkirchen Company, and will be at work in the course of 12 months, and certainly as it was worked in the Exhibition nothing could be more complete than the control of it.

10787. Then I gather that you think in this country we are going to sleep?—We are slow in making new departures. The Germans are rather inclined to go perhaps too fast the other way. But there can be no doubt about this: I myself am burning about 30,000 tons per year for colliery consumption, which might be reduced very considerably.

10788. To 10,000 tons, I suppose?—Perhaps to 10,000 tons. I may say this, that I put before my Board the proposition that by the expenditure of £15,000 we could save £4,000 per year by substituting the Mond system, and making sulphate of ammonia to the value of 4s. 6d. per ton of coal carbonised. We take our firing stuff at 4s. 6d. per ton for book-keeping purposes, and you can get, with the Mond system, out of our coal, sulphate of ammonia, which will realise 4s. 6d. per ton, if you assume it is at the price of £11 per ton; and that would practically cancel your coal bill, because you would get the value in the sulphate of ammonia to pay for your coal.

10789. Then 30 per cent. is not an attractive rate of interest for colliery management?—The collieries are very poor—they are fleeced by everybody.

10790. They cannot have much credit, either?—And perhaps there is a little want of faith in their managers.

10791. Have you any experience of Belgium?—Not very much.

10792. You spoke of deep mining in Germany. What is the deepest mine you know—900 yards?—I think so. I think about 850 metres.

10793. We have something deeper than that here in this country?—Yes. It occurs to me that the question of deep thick seams in Yorkshire and Lincolnshire, at any rate, is a very much more practical one than the question of working very thin seams. If only the heat difficulty can be surmounted, there is every reason to suppose that east of Doncaster there are any number of very valuable seams. I do not know what evidence you have had upon that point, but certainly between Doncaster and the Trent, and probably considerably east of the Trent, there is an immense coalfield, and the chances are that it contains very thick and good seams. It is certainly over 1,000 yards—3,000 ft.—to the Barnsley seam.

10794. But we have some collieries even deeper than that in this country, have we not? Pendleton is more than 3,000ft. deep, is it not?—Yes, I daresay it is.

10795. There are no difficulties about heat there. Then you anticipate that the coalfield in Lincolnshire extends to the east, but is deeper?—I do not think we may say it is getting deeper, but the Barnsley seam is 3,000 feet deep and there are many other seams lower than the Barnsley. I do not know whether any member of the Commission knows the geological particulars, but we assume that we have reached the bottom of the syncline at Doncaster, or thereabouts, and that it is not deepening.

10796. It flattens out, does it not?—Yes, and if it is a syncline it will tend to rise to the eastward, although it is overlaid by secondary strata; it is possible that as you go further to the east, you may find the coals are rising eastward.

10797. (*Sir George Armytage.*) I daresay you have heard that there has been a shaft sunk somewhere in the direction of Haxey?—No, only a bore-hole.

10798. At what depth did they find the bed there?—That is the one I am referring to in Lincolnshire at about 1,000yds. deep, which is called South Carr.

10799. (*Chairman.*) They have only put a bore hole, you say?—Yes, only a bore hole. There is no doubt whatever, I think, that there is an immense amount of coal there.

10800. (*Mr. J. S. Dixon.*) But you were going to speak about the difficulty of working, owing to the thickness of the seams?—Yes, I think there is an immense amount of coal there, if it can be worked, having regard to the heat, if we do not get too deep. Certainly in Westphalia they anticipate that at least half their coal will not be workable on account of depth.

10801. (*Chairman.*) But there is no reason to suppose that in the district to which you refer, the temperature at 3,000ft. deep will be any higher than it is at Pendleton at 3,000ft. deep, is there?—No.

10802. Therefore, does not that answer the question as to whether there will be any difficulty there?—I think your Secretary told me he had Professor Stassart's paper on the deep mining in the Mons district.

(*Chairman.*) We have a great authority on the subject, and he is just entering the room. Professor Dixon, we have just arrived at your point; we are just discussing the ability to work at 3,000ft. deep, and I asked Mr. Blake Walker whether there is any reason to suppose that in Lincolnshire, for example, the temperature would be any higher at 3,000ft. than it was in Pendleton in Lancashire, because we know it was worked there at that depth.

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Mr. George Blake Walker
24 Feb. 1903.

(*The Witness.*) I was going a little further ; I speak under correction, because I have not looked it up, but I think Professor Stassart took temperatures at 3,600ft. at Les Produits Collieries, in the neighbourhood of Mons or Charleroi, and there the output of the miners was materially reduced by the temperature, and they found it was exceedingly difficult to reduce the temperature of the air. That paper* is full of most valuable information.

10803. (*Chairman.*) We have temperatures at much greater depths than that—Greater than 3,600ft. ?

10804. (*Chairman.*) Yes.

(*Professor Dixon.*) The deepest in Belgium was 3,900ft, at the Sainte Henriette pit. It was exceedingly hot there.

10805. (*Chairman.*) You will not be surprised to hear that there are much deeper pits in America than that ? --There are the copper pits.

(*Chairman.*) Yes, at Lake Superior.

(*Professor Hull.*) Those are no criterion to go by, because they are in an entirely different position.

10806. (*Professor Dixon.*) In the tables we first had with regard to the temperature in the Hecla and Calumet mine, the formulæ given us were wrong. The temperatures actually are not nearly so high as they are in the Pendleton coal pit ; they are cooled by the cold water of Lake Superior. So that we must not go by the Hecla and Calumet pit at all. That is, as you know, 4,900ft. deep, and the temperature is not much over 80°, but at Pendleton they are working at 3,480ft. now ?—In reading Professor Stassart's paper, the point which seemed to me to be the most pertinent to this matter, is this, that at about 600 yards from the shaft, no matter how cold it was, whether it was winter or summer, the air had taken up approximately the temperature of the surrounding strata, and unless you can by some means cool it again, it continues at that temperature on to the men and very much reduces their power of work.

10807. (*Mr. J. S. Dixon.*) Probably it might be made cooler. I do not think there are any insuperable difficulties ?—No, I do not think there are insuperable difficulties. I think it is a point which will be of great importance in the future.

10808. (*Chairman.*) Subject to that I gather you think there is a very great field to the east or south-east of Doncaster ?—Yes. I think there is no question about it that that is the most important coalfield the country possesses.

10809. I understand you say that at 3,000ft. there is quite a considerable and valuable bed of coal which would be available if the temperatures did not stop the working of it ?—I should like to supplement that. The Barnsley seam is practically the uppermost of the South Yorkshire series ; below the Barnsley you have quite a number of seams ; for instance, the Park Gate and the Silkstone ; and what I meant was this, that there is no doubt you can work the Barnsley at 3,000 ft., and, if I am right in my opinion, that that is the maximum depth at which the Barnsley exists between, say, Doncaster and Gainsborough, and that beyond that we are at the bottom of the syncline, then there is no question as far as the Barnsley bed is concerned, which is after all the most important. But then there are all the other seams, and to go to them would mean the addition of another 1,000ft.

10810. Making 4,000ft. ; that is the limit of depth that we have set before ourselves as being practicable at present ?—I think you are not far wrong in taking that depth.

10811. (*Sir George Armytage.*) But have you not heard, or do you not suppose, that this Barnsley seam when it gets to the eastward of Doncaster separates and becomes too small a seam ?—Well, it is not necessarily thinner, because in one case the division of the seams has resulted in two seams, each nearly as thick as the seam was further west.

*Les Conditions D'Exploitation à grande profondeur en Belgique par M. Simon Stassart. Extrait du Bulletin de la Société de l'Industrie Minérale. Troisième serie, Tome xiv, 1900.

10812. Is that so ?—Yes ; but that is not the case at the South Carr bore.

10813. (*Professor Dixon.*) Have they gone below the Barnsley seam there anywhere ?—No, they stopped at the Barnsley seam.

10814. And there are seams underneath this which you think might be workable except for a possible stoppage by reason of temperature ?—I should be very much surprised if there is not a whole series. With regard to the particular seams, of course we find that some seams which are workable in one part of the coalfield are not workable in another part, and others become more valuable than they were to the west. But the Barnsley seam has been so much the best seam that the others have not been proved further east, I think, than Manvers Main.

10815. What was the thickness found at South Carr ?—My impression is that both the two divisions of the Barnsley seam were under 5ft.—between 4ft. and 5ft. each.

10816. (*Chairman.*) I understand they are the top seams ?—There are the Shafton and Abdy and one or two other seams which were sunk through, and if my memory serves me one of them at least is a workable seam.

(*Professor Hull.*) My Lord, I have that boring of South Carr here, and I have all the details of it ?

10817. (*Sir George Armytage.*) What is the date of the South Carr boring ?—About 1875. The whole of the information is in the Transactions of the Institution of Mining Engineers in a paper read by Mr. Dunston.

10818. In your statement you say that the coal (engine slack) is sold at a price usually below the cost of production ?—Yes.

10819. Is that really so, that it is absolutely sold at a price below the cost of production ?—Certainly. The cost of production is in very few cases at the present time under 7s. per ton on the average, and it varies from that up to 9s. per ton, so that if engine slack is sold at the pit at 4s. or 5s. per ton, it is obvious that it is sold considerably under the cost of production.

10820. You mean under the cost of production of the other coal—of the whole field ?—Well, you must average your sales if you average your cost. If, for the sake of argument, you adopt a figure of 8s. per ton as being the cost on the whole of the coal raised at a colliery, if 25 per cent. of it is coked and realises 4s. 6d. per ton, and another 7 per cent. is used for colliery consumption and realises nothing, then you have——

10821. But you are taking the average cost of production all round ?—Yes.

10822. You are not taking the average cost of production as proportioned to the selling price ?—Divide the amount of money received for the coal by the number of tons raised, and it will come, according to the condition of the colliery, to somewhere between 7s. and 9s.

10823. Then you say it is dirty and generally unscientifically used. Do you mean by that that it is not washed and made the most of ?—I think it is common knowledge that the ordinary firing of boilers with the shovel on the ordinary fire-bar does not get the heat out of the coal which ought to be got out.

10824. Then you do not mean that it is unscientifically used at the colliery, but it is unscientifically used after it has gone into the market ?—Yes.

10825. Then is it not worth your while to clean it and to use it more scientifically at the collieries ?—I do not quite understand you.

10826. What I mean is this ; you say here that you have got a product which comes from your colliery and which is sold for less money than it costs you to produce it. You say that it is unscientifically used and is dirty. If that is the case, would it not be worth while to use that for your own boiler purposes after having cleaned it ?—No ; I say that it would be better if the coal were washed and sold in a graded condition and freed from the dirt ; I think a better price would be obtained for it, and then, when the consumer got it, he would use it in a furnace scientifically constructed.

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10827. Quite so. You have a washing plant, have you not?—Yes.

10828. Why do you not wash the coal before you sell it. That is what I want to arrive at?—We find it is only necessary in our case to wash our coking coal; the other coal is fairly clean without the necessity for washing.

10829. Then this is not coking coal?—Yes, it is coking coal; it is gas coal really, but the smallest of it is used for coking.

10830. You spoke about coal dust being used for fuel by blast, the same as petroleum is used in locomotives?—Yes.

10831. Where is that done?—In Berlin more than anywhere else, where they will not allow any smoke. But Mr. Bryan Donkin had several furnaces tried here in Southwark, and he contributed papers on the subject to the Institution of Civil and Mechanical Engineers.

10832. But that was for stationary engines, was it not?—Yes.

10833. Do you know of any instance in England where it has been tried for locomotives?—Oh, I did not mention it with regard to locomotives.

10834. (*Dr. Le Neve Foster.*) You were talking about the worm disease in Westphalia. Are you aware that watering has led to an increase of that disease lately?—I know that they keep the places very wet; watering has been very much overdone.

10835. Are you aware that the disease has generally increased since they have introduced watering?—When you put it in that way, I think it is the case, but I have never connected the two things together in my own mind.

10836. From what I have learnt lately, the statistics show that after watering was introduced, the disease increased very highly in Westphalia?—I should think it is very probable.

10837. The number of cases increased very largely. You were talking about washers. What would you consider is the best form of washer nowadays. Would you say that the Luhrig plant is old-fashioned?—But the Luhrig people now make a very much better one. There are several people who make excellent washers. The one in which the separation is effected after washing is the improved Baum washer, and the old Baum is certainly second to no other. But there are Schuchtermann and Kremer, and the Humboldt people, and quite a number of firms who make excellent washers.

10838. They are all of German make?—Well, Sheppard's in South Wales, I think, is not dissimilar in principle, but you may say they are all either of German make, or in imitation of the German principle.

10839. (*Mr. Brace.*) There are several in England, are there not?—Several makers.

10840. The Hardy Patent Pick Company make washers, do they not?—Yes, but they are quite small things comparatively.

10841. (*Dr. Le Neve Foster.*) Is it not a matter of fact that they have supplied them to some of the collieries in the north of France, on a large scale?——

(*Mr. Brace.*) And to Austria.

(*The Witness.*) That is not within my knowledge, but of course it is very probable.

10842. (*Dr. Le Neve Foster.*) Is the dust system of firing that one of the Cyclone Company?—No, I did not know that it was applied to boiler firing. Is not the Cyclone a grinding machine?

10843. There is a Cyclone Company with a dust firing of coal for boilers?—Then the Cyclone machine would be used for pulverising the dust.

10844. No, it is called the Cyclone Company for dust firing, and the system is in use in London?—Yes.

10845. That is not the system you are speaking about?—No, I was speaking of the Schwartzkopff and the Wegener systems.

10846. What size was that electrical winding engine you spoke of at Düsseldorf?—I think 800 h.p.

10847. (*Professor Dixon.*) Are you using any coal cutting machinery in your mines?—Yes, a large number of machines.

10848. (*Mr. J. S. Dixon.*) You have said that some of the firms are now beginning to wash the whole produce of small coal together, without separating it?—Yes, that is so abroad.

10849. So I understand. Is not that a backward step?—I do not think we can say so. They claim that it is an improvement. The largest and richest mining company in Westphalia, the Gelsenkirchen Company, have just put up such a washer at their most modern colliery, and they are very well satisfied with it.

10850. That was the original process in the part of the country I come from, and we think we have improved upon that by separating it?—Well, they have harped back to this, and they are certainly getting very good results. I, like you, was inclined to think that the other was the right way, but I am told that undoubtedly this thing works very well.

10851. You speak about the economy of 1s. per ton in cleaning the coals. Is that as compared with hand-picking and washing? I did not exactly catch what that shilling per ton comprehended?—If a colliery which has no washer wished to treat a large part of its output, say 50 per cent. of its output, by washing, I believe they could save upwards of 1s. per ton by the erection of a washer to do all that work.

10852. They could increase the value of the product?—No, I do not mean that altogether; there would also be a saving in wages.

10853. As compared with hand-picking?—Yes.

10854. I think you spoke as if the separation of coal into a considerable number of sizes was not very universal in this country?—Well, I said large coal, large nuts, pea nuts, and slack was the usual division.

10855. In the practice I am accustomed to, we separate it into six different sizes?—By dry separation?

10856. No, by washing.—But I am speaking of by dry separation.

10857. I beg your pardon, I thought you meant by washing. With regard to this Dusseldorf electric winding engine, was it doing any actual work there?—No, it was simply being run round to show the manner of manipulating it.

10858. Reversing and so on?—Yes, it was not working against a brake, if I remember rightly.

10859. (*Chairman.*) But you did say something about one being in operation in Russia, did you not?—There are six pits, each fitted with an electric winding engine.

10860. (*Mr. J. S. Dixon.*) And there are some in this country; there is one in Lancashire, of which I have seen an account. Then as regards the difference between washing and selling the small coal, as you do without washing, I suppose there is a certain price at which it is better to sell it as small coal than to wash it. You get a certain price for your small coal?—Yes.

10861. And it is better to sell it as such, than to wash it?—Yes.

10862. In your statement you speak about a great number of seams of coal with interstratified beds of shale. Do you not anticipate that those could be worked and the produce—dirt and everything—put into a Mond producer, and that that would give gas—put the whole thing in as it comes out of the pit?—Well, the dirt has all to be removed from the bottom of the producer. You would not get as good results out of the Mond producer if you put a great deal of dirt into it.

10863. Some of the evidence that we have is, that the Mond producer can give gas from very inferior fuel?—Yes.

10864. Looking to the resources of the country, if we can make use of those dirty seams by such a process, it would be an advance?—It would be a method of dry separation or hot separation.

10865. Taking the gas out of it, at any rate, and taking out the dirt?—Yes.

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Mr. George Blake Walker

24 Feb. 1903.

10866. (*Mr. Young.*) Have you any experience in deep mining? What is the greatest depth that you have any experience in working?—Do you mean in my own colliery where I have had charge?

10867. Yes?—Well, I think about 560 yards; that is not any very great depth.

10868. Have you ever found any difficulty at that depth on account of crush?—One seam might give you no trouble if it had a good rock roof, and another seam with a bind roof might give you a great deal of trouble.

10869. But with the same seam under similar conditions, one, say, at 1,500 or 1,800ft., and the other at 1,000ft., the difficulty would be increased at 1,800ft., would it not?—I have found a great difficulty in the same seam at much less depths than that; for instance, in a certain seam down to a depth of 300 yards, we had little trouble with the roof; it went through a fault, only making a difference of 50 yards more, and from that point onwards we had enormous difficulties, and had to change our system of working; but I attributed that less to the superincumbent weight than to gas pent up in the roof which burst it down. The roof was alive, and we were obliged in that case to make very wide winning roads, 40 yards wide, for the purpose of allowing the roof to break up and relieve the gas. That was not a question of superincumbent weight.

10870. You have no information of a practical character to give with regard to what the difficulty might be at 4,000 ft.?—I think that in every case the nature of the strata has a great deal to do with it. Even at 4,000ft. you might have a seam which would work well if there was a good roof.

10871. (*Mr. Teall.*) You have examined the evidence obtained from the comparatively recent borings as to the extension of the coalfield eastwards?—Do you mean in Yorkshire?

10872. Yes—Yes.

10873. And you see no evidence of the deterioration of the coal seams towards the east?—I think not. At Denaby and Cadeby and South Kirby, which are the collieries furthest to the east, they have had trouble with gob fires, which may be local to the seam. I do not think you can draw any general inference from that. The quality of the coal has remained as good as ever.

10874. That is owing to the thickness of the seams?—Yes. In the seam at South Kirby they have reached the point where it divides, and undoubtedly as you go further to the east the upper and lower parts of the Barnsley seams diverge.

10875. (*Chairman.*) Is the Nostell colliery a little further east than the Kirby?—No, it is a little further west, my Lord. They are not working the Barnsley yet.

10876. (*Mr. Teall.*) So that you would have no hesitation in including a very large area to the east in the coalfield in estimating the future resources?—If a personal opinion is of any value whatever, I have great confidence that there is an extension of the coalfield considerably east of the Trent. I should not like to say that it is quite out of the question that it may extend as far as Grimsby.

10877. Is there any evidence at present as to where the beds begin to turn up again on passing to the east?—If you put down the measures on a very large scale from the outcrop on the west, you find they form a parabolic curve, gradually flattening until at South Carr they appear to be level. It you continue the parabolic curve as a synclinal curve it may commence to rise in an easterly direction, but of course that is not by any means certain.

10878. (*Professor Hull.*) I was going to ask you whether you agree with the paragraph in this book on that subject of the extension of the Lincolnshire and Derbyshire coalfield?—Is it your own?

10879. Well, it does not matter who the author is: "This great tract of coal producing strata," that is the Derbyshire and Nottinghamshire coalfield, "though occupying portions of three counties, is physically one coalfield. It is the largest coalfield in England, having an area of 760 square miles between the Millstone Grit on the one side and the Magnesian limestone of the Permian formation on the other"?—It underlies the Permian.

10880. Yes, but that is the visible coalfield I am referring to, you see?—I beg your pardon, I understand.

10881. "Its absolute limit in the direction of the sea coast has not yet been proved, and is possibly beyond determination by boring experiment, owing to the great and increasing thickness of the overlying strata. But the recent successful boring at South Carr, near the banks of the Trent, by which the 'Barnsley hard' coal, nearly 5ft. thick, was penetrated at a depth of 3,181ft., proves that the coal-measures stretch considerably eastward of this position. There seems every probability on geological grounds that the North-Midland coalfield is but the visible portion of a great basin, the eastern side of which is concealed by newer formations. This question I have elsewhere discussed at some length, and it is a view generally accepted by geologists"?—The only point that I should like to make with regard to that is that the boundary of the coalfield to the south

10882. Near Nottinghamshire?—Yes—appears to be tending northward. I do not think you can assume that running east from Nottingham itself you will meet with coal. I think it tends in a north-easterly direction.

10883. Exactly; I agree with you there; I agree with that view as to the limit of the concealed basin.—Yes.

10884. (*Sir Lindsay Wood.*) With regard to coal-cutting, I think you are almost the only person who has a colliery worked entirely by coal-cutters?—Yes, that is the Lidgett colliery, but I have several seams at the Wharncliffe-Silkstone colliery worked with coal-cutters too.

10885. What sort of a coal cutter is it that you are using?—The disc type.

10886. You do not use any of the Firth machines now, I suppose?—I do not think there are any at work now.

10887. What power do you use; electrical, or what?—We have used compressed air until about three or four years ago, but we are now substituting electricity.

10888. Do you find electric power is satisfactory?—Yes, certainly; much more economical and much more powerful.

10889. Is it at a long distance from the shaft?—Yes, 1,000 yards; that is the electrical machine. The others with compressed air we have a good deal further, a mile or so from the shaft.

10890. Do you find the cost of conveying electricity is less than the cost of conveying compressed air?—Yes; and the great point is that with the compressed air you are constantly losing pressure. The further you go the more pressure you lose, but in the case of electricity if your conductors are all right and if you have a cable of sufficient capacity you do not lose pressure.

10891. (*Chairman.*) Is there any trouble about sparks?—I think one may safely say that if you properly box in the motors there is no danger of igniting gas; on the other hand no prudent colliery manager would use an electrical machine where he knew there was gas; if an accident did occur it could only happen from the unexpected presence of gas.

10892. (*Professor Dixon.*) How do you put in your cables—the fixed leads to the machines? Do you put them on the roof, or do you bury them?—No, the best leads that we have put in have been for pumping. We went to considerable expense in that case in cutting out a groove in the wall of the coal road, and carried the cables in that groove.

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10893. In a casing? — No, they are simply well-insulated cables about 1½in. in diameter — bitumen cables—and they are carried along on supports about every 15ft. in this groove, so that we consider they are safe from falls of roof.

10894. And, as a matter of fact, you have had no breakages in those?—I was going to say that when we got a certain distance in, the coal has been all got out, and we were obliged then to carry them in the timber. We then supported them on boards; as well as hanging them from the timber, we thought it advisable to put boards under them, so that they were not hanging by their own weight. We have had the cables knocked down once or twice, but they were not injured.

10895. Not broken?—No. Generally speaking, we have carried our cables in on the timber, and if possible on opposite sides of the way, so as to obviate any chance of the two cables being brought together by a fall and short circuit.

10896. Then you are carrying the current now by these cables to the cutting machine, I understand?—Yes.

10897. How much movable cable do you find necessary from the ends of the fixed ones to the cutting machines?—About 50 yards double cable.

10898. How do you deal with that? Have you had any difficulty with it?—It is a non-gaseous mine, and they are light cables without armouring, and they are not bad to pull about. Of course, sometimes the insulation gets worn off, and in that case the worn parts ought to be cut off.

10899. Do you fasten them on the walls or put them in the ground?—No, they lie on the floor.

10900. Do you not find they get kicked?—Yes, they are lying on the ground. You see, if your gates are 40 yards apart, and you only have a switch in the alternate gates, you must have at least 40 yards of cable to reach along the face.

10901. Exactly, and you have that along the ground? —You have that along the ground, and it is simply bundled up when they remove it from one gate to another.

10902. Have you had any breakages of that loose part of the cable?—Well, yes; naturally there is a considerable wear and tear.

10903. You have had it sparking, I suppose?—Yes, but it is a pit where you can use candles, if you like.

10904. Has it lighted the coal dust or the coal at all? —There is no coal dust there. I do not think that in any case it would be likely to light such coal dust as you would have in the face in working. It is the fine coal dust on a haulage road, blown off the coal and almost impalpable, that is so liable to be ignited.

10905. That is the explosive dust?—And ignitable dust; but it is gritty in the face, and I do not think grit dust is likely to be ignited by an electric spark.

10906. As a matter of fact, you have not had any fire? —No, and I may add this, that with the coal-cutting machines the coal and the ground below is always covered with a fine shale, not with coal.

10907. You are doing all your cutting in the clay or in shale?—Well, there are several seams, and we do not always cut entirely in the shale, but we try to.

10908. Are the seams which you are working with these coal-cutting machines pretty level?—About 1 in 12—3in. to the yard.

10909. You have had no difficulty from that incline, in working the machines?—They are level faceways on—the way the machine works is practically level, but they work perfectly well on steep grades.

10910. Have you experience of working them on steep grades, where you are working upwards with the incline?—I have seen them working on steep grades.

10911. How steep?—I should think about 1 in 4.

10912. (*Professor Hull.*) Are you speaking of Yorkshire or Derbyshire?—I am speaking of Yorkshire with regard to these coal-cutters.

10913. (*Professor Lapworth.*) What part of Yorkshire?—In the neighbourhood of Barnsley.

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COMPARISON OF THE RELATIVE COST OF COAL-GETTING BY HAND AND BY MACHINE (Question 10,772).

	In a Seam 3 ft. thick.			In a Seam 2 ft. 6 in. thick.			In a Seam 2 ft. thick.			In a Seam 1 ft. 6 in. thick.		
	Nature of Holing.			Nature of Holing.			Nature of Holing.			Nature of Holing.		
	Favourable.	Hard.	Very Hard.	Favourable.	Hard.	Very Hard.	Favourable.	Hard.	Very Hard.	Favourable.	Hard.	Very Hard.
	s. d.	*s. d.*	*s. d.*	*s. d.*	*s. d.*	*s. d.*	*s. d.*	*s. d.*	*s. d.*	*s. d.*	*s. d.*	*s. d.*
Price for getting Coal by Hand, per ton	1 6	1 7	1 8	1 10	2 0	2 2	2 6	2 9	3 0	3 3	3 7	4 0
Percentage of Slack by Hand	40	40	45	45	45	50	50	50	55	55	55	55
„ „ „ Machine	20	20	20	20	20	20	25	25	25	30	30	30
	s. d.	*s. d.*	*s. d.*	*s d.*	*s. d.*	*s. d.*	*s. d.*	*s. d.*	*s. d.*	*s. d.*	*s. d.*	*s. d.*
Average Selling Price per ton: Round (including Nuts), at 6*s.* per ton. Hand	4 7·2	4 7·2	4 5	4 5	4 5	4 3	4 3	4 3	4 1	4 1	4 1	4 1
Slack, at 2*s.* 6*d.* per ton Machine	5 4	5 4	5 4	5 4	5 4	5 4	5 1½	5 1½	5 1½	4 11½	4 11½	4 11½
Price for filling out Coal when Coal is Holed by Machine	1 0	1 0	1 0	1 3	1 3	1 3	1 10	1 10	1 10	2 6	2 6	2 6
Yards holed by each Machine per day of 16 hours	140	105	70	140	105	70	140	105	70	140	105	70
	Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*
Holed by 7 Machines per day say	1,000	750	500	830	620	415	666	500	333	500	375	250
„ „ in 250 days say	250,000	190,000	125,000	207,500	155,000	103,750	166,500	125,000	83,250	125,000	93,750	62,500
	d.	*d.*	*d.*	*d.*	*d.*	*d.*	*d.*	*d.*	*d.*	*d.*	*d.*	*s. d.*
Cost per ton (based on previous Estimate) for Holing by Machine	3·1	4·2	6·3	3·8	5·1	7·6	4·8	6·3	9·5	6·3	8·4	1 0·6
	s. d.	*s. d.*	*s. d.*	*s. d.*	*s. d.*	*s. d.*	*s. d.*	*s. d*	*s. d.*	*s. d.*	*s. d.*	
Total cost of Coal-getting by Machine	1 3·1	1 4·2	1 6·3	1 6·8	1 8·1	1 10·6	2 2·8	2 4·3	2 7·5	3 0·3	3 2·4	3 6·6
Saving as compared with Hand labour	0 2·9	0 2·8	0 1·7	0 3·2	0 3·9	0 3·4	0 3·2	0 4·7	0 4·5	0 2·7	0 4·6	0 5·4
Saving in yield of Coal (value)	0 8·8	0 8·8	0 11	0 11	0 11·0	1 1	0 10·5	0 10·5	1 0·5	0 10·5	0 10·5	0 10·5
TOTAL SAVING	0 11·7	0 11·6	1 0·7	1 2·2	1 2·9	1 4·4	1 1·7	1 3·2	1 5	1 1·2	1 3·1	1 3·9

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EIGHTEENTH DAY.

25th February 1903.

PRESENT:

THE CHAIRMAN.

Sir GEORGE ARMYTAGE.
Sir LINDSAY WOOD.
Mr. BELL.
Mr. BRACE.
Professor DIXON.
Mr. J. S. DIXON.
Dr. LE NEVE FOSTER.
Professor HULL.
Professor LAPWORTH.
Mr. SOPWITH.
Mr. TEALL.
Mr. YOUNG.

The Secretary.
The Assistant Secretary.

Mr. EMERSON BAINBRIDGE, called; and Examined.

Mr. Emerson Bainbridge.

25 Feb. 1903.

10914. (*Chairman.*) You are Consulting Engineer, I understand, to collieries raising about 15,000 tons per day?—Yes.

10915. You have taken a great interest in labour-saving machinery for various departments of colliery sinking and working?—I have.

10916. Will you deal with that subject first?—Yes. These various collieries are nearly all under different conditions and in different counties, the counties being chiefly Durham, Yorkshire, Derbyshire, Nottinghamshire, and Warwickshire. In certain cases we have developed coal-cutting very largely. I am now cutting about 3,000 tons of coal per day, which I think is a very much larger portion of the output than is generally the case. But we have had to face the same difficulties in cutting as other collieries, which very much restrict the application of coal-cutting.

10917. (*Mr. Brace.*) You refer to coal-cutting machines?—Yes, cutting by machinery. There are difficulties which very much restrict the scope there is for adopting coal-cutting machinery. I need not go over that ground. Probably the Commission have already had placed before them again and again the difficulties there are in the way of generally adopting coal-cutting.

10918. (*Chairman.*) Shortly stated, they are inclination, thickness of seam, faults, and so on?—Badness of roof, tendency of coal to tumble over, and softness of holing. Those are the difficulties. Where those difficulties do not exist we have very largely adopted coal-cutting.

10919. Will you tell us at this point whether in the cutting of 3,000 tons per day the machinery is applied to many mines, or is it applied to a few of the whole?—About five, at which about 400 to 500 tons per day are cut by machine. There are various machines. Electric and compressed air are the only two kinds of motive power there are.

10920. You use both, do you?—Yes, we use both.

10921. Is that determined by the condition or character of the mine?—Not particularly. It is very often the existence of the electric motive power on the surface which induces one to use the electric motive power below, especially where we know there is an absence of gas. Generally speaking, I might mention that we estimate the saving in coal-cutting, where we find it a success, to be about 6d. per ton under favourable conditions, but under unfavourable conditions that dwindles down to hardly anything. On the other hand, if there was no saving in cost, we should probably pursue it on the ground of it being a great help in the application of skilled labour.

10922. Does it enlarge the output?—It does; in cases where it is working under the best conditions it enlarges the output by about 10 per cent.

10923. Is 6d. per ton the difference between the cost of getting by hand and the cost of getting by machine?—No; I should average the difference arrived at as 3d. in the saving of labour and 3d. in the saving in the value of coal. Of course, that may vary sometimes from 2d. to 4d., either one way or the other.

10924. Quite so, but the 6d. is a saving after making allowances for depreciation, outlay of capital, and so on?—Yes, under the best conditions. I do not know that I need say much more about coal-cutting unless other questions arise; but I might mention that in other matters of mechanical work we very largely use the mechanical drill.

10925. May I ask this further question about it: is it found that the workman using or having the coal-cutting machinery as his aid earns as much money?—Generally rather more.

10926. (*Mr. Brace.*) Before you leave the subject, may I put this one question? Does the use of coal-cutting machines give you a higher percentage of large coal than you get by hand labour?—That is how I arrive at the extra 3d. due to the extra quantity of coal: it is because it gives more large coal that we get the extra 3d.

10927. (*Mr. Young.*) When you say the miner earns more by coal-cutting machinery than by hand labour, do you mean that the whole of the men engaged at the machine earn more?—I mean the whole of the men at the face. There may be one skilled man driving the machine and other men helping him.

10928. And the average of the whole will exceed the average of the hand-getting?—Yes.

10929. (*Chairman.*) You are quite clear about that, Mr. Bainbridge, are you, because there is an interesting point upon that. The average of the whole, as I understand Mr. Young's question, would be the average of the whole of the men employed?—Put 100 men into the face working by hand, and use the same 100 men working by machinery.

(*Chairman.*) That is not quite his question, I think.

(*Mr. Young.*) Yes, I think it is.

(*Witness.*) The increase will be manifest.

10930. (*Chairman.*) The men working at the face using the coal-cutting machines?—Yes.

(*Chairman.*) I thought your question, Mr. Young, might be taken to mean on the average of the whole of the men employed, including, if you like, those who are assistants only.

(*Mr. Young.*) Yes, that is so, but I think the answer applies.

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Mr. Emerson Bainbridge.

25 Feb. 1903.

(*Witness.*) I perhaps rather misled you on the question of the earnings, because, if you have 100 men, naturally the men who drive the machines get their wages very much more increased than the ordinary man who fills the coal. You follow what I mean by that?

10931. (*Chairman.*) Perfectly.—The ordinary filler's wages would not be increased much.

10932. (*Mr. Young*) Your answer covers the point as put by the Chairman. I understand that both the skilled men and those who assist on the face actually get more on the average than the same number of men working by hand?—On the average, I think they will. I do not know whether you have had any evidence brought before you with regard to other kinds of coal-cutting by the rotary machine which drives coal drifts.

10933. (*Sir George Armytage.*) What was the machine you were referring to previously?—The machine I was referring to is the machine for working longwall, by cutting the face underneath from 3ft. to 5ft. below. The machine I am now referring to is one for driving long coal drifts. If you have had the Stanley machine mentioned I need not refer to it any further. I use a very large number of them.

(*Chairman.*) I think it would be interesting if you will tell us what you have to say about them.

10934. (*Mr. Brace.*) I should like you to explain to the Commission how the day-wage workers—the fillers, if you like—have increased their wages. How do the fillers increase their wages by machines over and above filling by hand labour?—I did not mean to indicate that they had increased them, but Mr. Young asked the question whether, on the average, they make more? I should say yes, but the filler does not make much more.

10935. Then how do you prove that on the average they make more?—Because I should think the skilled man would make very much more, and the skilled man will raise his average so much as to raise the filler's wages as well.

10936. I agree. So that, as a matter of fact, it is only the actual operators with the machine who get more wages?—Chiefly the actual operators.

10937. And not the assistant?—I do not think the assistant will, except to a small extent.

10938. (*Dr. Le Neve Foster.*) But the assistant eventually becomes an operator himself, and so gets more?—If he is a man with any enterprise at all he becomes an operator, and therefore he would raise his wages.

10939. In that way it is a gain to him to give him the chance of becoming an operator?—Yes, it would be so if he chooses to accept the gain.

10940. (*Mr. Brace.*) But as a filler he would not get his wages raised?—He would slightly. With regard to the Stanley machine, it is simply really a mode of economising the driving of a drift, especially with regard to speed. If you have a coal seam more than 4ft. high, which we have in Warwickshire, for instance—they go up to 6ft. and 7ft.—you can get, in driving a drift, practically two and a-half times the speed, I should think—under good conditions again—with a machine like the Stanley, to what you can by hand. The effect is, at the same time, whilst going very fast, to form a kind of arch in the coal—the very fact of the machine working in a circular manner does that—which rather protects the roof as well. Therefore, in opening out a district upon what is called the longwall system by headings, you can open it out very much faster and very much more economically, and also in cases where you have difficulty in ventilation the very fact of the air coming from the air machine which drives the drill helps to ventilate the roads, especially where they are going downhill.

10941. (*Sir George Armytage.*) That is a sort of tunnel-driving machine?—Yes, a sort of tunnel-driving machine, not applicable to stone, but applicable to coal.

10942. (*Chairman.*) Are they being largely used?—I do not know that anybody has used them so largely as I have, but I think they are pretty largely used. I have used them, and found them not to answer in some cases.

10943. (*Sir George Armytage.*) Are those used only for opening out, or are they used for working afterwards?—I think only for opening out—just for driving drifts.

10944. (*Mr. J. S. Dixon.*) You cannot work coal at a profit advantageously in that way?—For one very obvious reason—the very fact of using the machine grinds all the coal to powder, and therefore you only use machines in a drift.

10945. Yes, but some of them cut a periphery in the coal, in a circle, and you get round coal also then. I may say I have had great experience of them myself, but I could not work coal to a profit by them?—The machine with which it was tried to drive the Channel Tunnel worked in the way you mention; it cut a groove round. The Stanley machine generally does not do that—it grinds away. Then we also use very largely hand drills; I daresay you are familiar with these. They drive in coal in about a quarter of the time that an ordinary hand drill will in drilling coal.

10946. (*Chairman.*) Is that done by compressed air?—No, by hand. It is a machine that costs about £2.

10947. But you have not the power to apply to them yet?—There are plenty of drills that are used where power is applied. But this is driving in the coal face where you could not take power very well.

10948. Then in banking?—In banking I think there is almost as substantial a gain as in underground work in the careful laying out of new banking arrangements. In one colliery where I have laid out very carefully new banking work, I think one can estimate a saving of 3d. per ton by the application of a number of devices so arranged as to really dispense with the use of men, except for the brains of men, and to use boys, or very young men, for keeping the work going. That is entirely done by doing all the uphill work for carrying trams by mechanical means and all the other work by gravitation. The same thing applies to the laying out of sidings at a large coal mine. I have two mines now raising about 2,500 tons per day each, where we have no locomotive; it is all done by gravitation; and the 3d. I am referring to is the effect of a combination of all these various conditions, including the carrying of coal mechanically over boilers and removing the ash mechanically under the boilers. Of course, I need not point out to the Commission that one great obstacle to that saving being obtained by many collieries is the difficulty they have in finding the money to spend; the ordinary colliery proprietor, under ordinary conditions, has not the capital to spend upon those labour-saving appliances, and in consequence of that he does not use them.

10949. But is there any difficulty in finding capital in this country for business which shows a profit?—Well, I hope to be allowed to say a few words upon that subject a little later, and I will try to indicate where the difficulty is.

10950. Do you wish to say anything about the use of machinery in sinking mines?—Yes. There has been a very great improvement made just now in sinking, applying the principle I was referring to. It is in operation now in Nottinghamshire. In the ordinary way of sinking a shaft, as I daresay most of the members of the Commission would be aware, there is a happy-go-lucky way of driving drills into the bottom of the shaft either mechanically or by hand, and an experienced shaft-sinker as a rule knows very well the best mode of laying out the holes for drilling to the best advantage; but with this new application, which I believe is applied for the first time, a ring is put down a shaft (the particular shaft I am speaking of is 25ft. in diameter, I think) and the whole ring is fixed with drills mechanically worked, which are dropped down the shaft all at one time, and all the holes are driven simultaneously and all the shots are fired simultaneously, and I believe they have been getting out 200 tons of rock at on time.

10951. To what depth do they drill at a time?—I do not know. The ordinary distance is from 3ft. to 5ft. in drilling in a shaft, and I should think that is the depth they drive. I have not seen the apparatus myself; I have only sent people to look at it; but I am going to adopt it at another colliery I am going to sink.

10952. The core is blown to pieces by the explosion of the cartridge?—The holes are drilled round, and the curved iron holding the drills is raised up, and when it is out of the way the explosion takes place.

10953. (*Sir George Armytage.*) Is the curved iron taken up to the top or lifted?—It is lifted a certain distance. Besides that, they have, I believe, an arrange-

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ment made for having a permanent arch over where the men are working which enables them to go on working continuously.

10954. (*Mr. Young.*) What is the explosive that is used generally?—I cannot tell you; nearly everybody uses a different explosive. This is at a colliery called the Sherwood Colliery, at Mansfield.

10955. Is it working?—It is working now, or rather it was working three months ago; they may have got into some different strata.

10956. Is it one of your collieries?—No, but I am going to start a colliery close beside it, so that we have been watching it.

10957. (*Mr. Sopwith.*) It is rather on the principle of Colonel Beaumont's first machine. I do not know whether you saw that. The difficulty that they had with that was that if the drills came against anything in the shaft it bent the drills. Are they able to keep the drills in a vertical position in the case you are speaking of?—I have not heard of that. I fancy the stone is very favourable to the drills. In the ordinary kind of limestone and coal measures which you have to go through in Nottinghamshire those difficulties do not arise.

10958. (*Professor Lapworth.*) Do they go down to the pebble, or do they commence where the strata is smooth in the red sandstone?—They had no pebble strata there at all; they were in the new red sandstone first of all, and then they passed from there to the coal measures.

10959. I can see it is feasible where you have regular even strata, but in pebbles, such as there are in some parts of Nottinghamshire, it would not be?—In pebbles I should avoid it.

10960. (*Professor Hull.*) You have not touched the new red conglomerate district in that part?—No, I think not.

10961. You are to the west of it?

10962. (*Mr. Young.*) How far apart are the drills?—I am not quite sure of that, but I should think about 4ft. I have not a plan of it here. Each drill averages about 15ft. an hour; they drill 51 holes, 6ft. deep, the time occupied being half an hour for each round, and something like 220 tons of material were removed after each drill. I thought that might interest the Commission, and I got these figures because, so far as I know, that is the first case in which sinking has been done in such an efficient way

10963. (*Professor Hull.*) What is the name of that particular plant and machinery?—I do not know the name of the machinery, but it is working, or was working, three months ago at the Sherwood Colliery.

10964. (*Dr. Le Neve Foster.*) As I understand you, it is a ring to which a number of drills are attached?—Yes.

10965. (*Chairman.*) Are the drills operated by power?—They are operated by air.

10966. (*Mr. J. S. Dixon.*) I suppose they are concentric, are they not, with one ring inside another?—Yes, exactly; there would be one ring inside another.

10967. The whole area of the shaft would be pierced by holes?—Yes, except the middle.

10968. (*Chairman.*) Do you wish to say anything further about machinery at this stage?—I have mentioned the sinking, the banking, the drifting, and the coal-cutting.

10969. And you have mentioned the sidings. You did not tell us how you got your wagons back without a locomotive?—We depend upon the railway company; they place them in position, and from the position where the railway company take them, they gravitate down. We were speaking about the question of the capital outlay. I should like to say, with all respect to the Commission, that there are difficulties arresting the development of the English coal trade, perhaps rather more serious than the mere question of saving.

10970. Do you start with the assumption that there is a decline in it?—I think there is less possibility of working coal to advantage in England, simply on the ground that we are now in England so much older as coalfields than countries like America, where they are working under conditions that we were working under, say, 50 years ago. I am just old enough to remember the time when in Durham we were able to put coal into trucks at 2s. 4d. per ton, including every item of expenditure, owing to the coal being worked by a drift into the hillside and the seam being thick and it being very easy to work with a strong roof. Those seams do not exist here now, but they do in America, and they do in China. Therefore, I take it, we have to face in this country a continuation of the higher cost, which we never can get rid of, and which would always handicap us against newer countries. On the question of capital, these last three years have done a great deal to help the colliery proprietor who was in difficulties to set his house in order. He has made money with which he has first of all paid his debts, and then he has tried to put his colliery right, and then he has paid dividends. If it had not been for those three years a great many of the collieries which have adopted labour-saving appliances could not have done so.

10971. It rather suggests the question to me as to whether his credit is not fairly good now?—Yes, it is very much improved. I was rather coming to that particular point: in the year 1897, the credit of the colliery proprietor was very bad; the banks were his chief friends.

10972. (*Mr. Young.*) Is the credit of the colliery proprietor as good now as it was two years ago?—If the credit of the colliery proprietor depends upon the margin of profit he is making, it is much worse. I do not know that it depends altogether upon that.

10973. Has it been gradually getting worse during the last two years?—Yes, gradually the margin of profit has been getting worse.

10974. Do you think it is as bad now as it has been at any time during the two years?—Oh, worse. There are a great many collieries now that are on the point of working at a loss, and a good many have been closed over the last two years; I have closed three myself because I could not make them pay.

10975. With regard to the prospect, looking forward to the next two or three or four or five years, do you think it is worse than it has been during the last three or four years?—I cannot speak about the prospect; it is impossible; that depends upon conditions which are hidden from us.

10976. Well, a colliery proprietor like yourself no doubt is always speculating more or less upon the probable future, I daresay?—The difficulty that a colliery proprietor has in this country now is that he cannot face starting a new colliery under an immense outlay. When he has to face the outlay for, say, 3,000 tons output per day, and he knows he must spend something like £300,000, he says to himself: "What have I to face, and what conditions have I against me?" That is why I made the remark about the labour question not being altogether the most serious; he has to look to the possibility of new legislation putting a bar upon him; he has to look to the unchanging character of the rates charged by the railways which take his coal away being somewhat of a bar to him.

10977. Is not that a much higher rate per ton expenditure of capital than has been calculated upon?—I do not make the calculation per ton, but as a rule if in one series of years your shafts are 150 yards deep, and in the next they are 500 yards deep, you are bound to have a very much higher expenditure per ton owing to the depth of the sinking, and every item of expense is very much increased.

10978. (*Chairman.*) Referring to the last point you have mentioned with regard to the unchanging railway rates, I suppose the conditions of legislation and of cost, which affect the cost to the railway company, do not alter as they do as regards the man who gets the coal?—I do not quite catch that point.

10979. Well, you are now speaking about coal costing more to get, and you have told us what you used to do in Durham at such and such a time?—Yes.

10980. As I understand, you take, I will not say a gloomy view, but at any rate a serious view of the position as regards the immediate future. You mention the possibilities of legislation; which might be adverse and might, as I understand you, increase the cost of the getting of coal?—Yes.

10981. The difficulty of getting capital is another point upon which you lay great stress?—Yes.

10982. Wages presumably are no lower; perhaps they are relatively high compared with what they were years ago. But are those conditions applicable to coal-mining only? Do they not apply to all other industries, including railways?—Yes, certainly. I am only

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Mr. Emerson Bainbridge.

25 Feb. 1903.

concerned for the moment with the production of coal. I am trying to do my best to indicate to you what barriers there are. I am not blaming the railway companies; I am only saying that one of the barriers to my spending another £300,000 upon a coal mine is the fact that I cannot look forward——

10983. It seems to me that the only point in your favour which you have mentioned is that the only thing which has not gone up is railway rates?—I might put it, perhaps, in another way, and say that whilst, in countries like America, in the last 30 or 40 years, railway rates have gone very substantially down, they have not moved in this country. I am not at all surprised, because the railway companies, like ourselves, year by year get into worse conditions by legislation and other burthens being placed upon their shoulders. That does not do away with the fact that such burdens damage the coal trade.

10984. When you say damage it, it is in the sense of tending to increase the price of coal?—And restricts the men who ought to be encouraged from opening out deep mines and from putting money into such deep mines. There is a large coalfield which stretches down from Leeds to Nottingham, and it has been known to be there for the last 30 years, but hardly anybody is opening it out now.

10985. (*Sir George Armytage.*) Does it not come to this, that the greater depth you have to go the more expensive it will be, and consequently the larger the area you ought to work at once?—Certainly; but that was not my point. That is a very obvious point with regard to the question of sinking deep collieries.

10986. Are there not difficulties by reason of the fact that you are unable to agree with a number of proprietors, where you might easily agree with one?—I do not think that would at all obstruct a man who wanted to work a colliery; he would go and spend his time in trying to make terms with the landlords, whether there were one or 50. I have sometimes one landlord and sometimes 250, but it does not make the least difference to me in taking the coalfield. The obstacles I was referring to were the large capital required and the uncertainity of legislation, such as what has happened with regard to the Workmen's Compensation Act, with regard to the export of coal, rates and taxes increasing, and the peculiar way in which they sometimes affect the mine. I may mention a case, if you will allow me, which occurred the other day, where the Assessment Committee endeavoured to raise the rateable value of the colliery. The case was taken into Court. The Assessment Committee lost. The whole cost of fighting this question was then placed upon the rates, and the colliery proprietor who won had to pay his proportion of those rates.

10987. Quite so—his own costs?—Yes, and the Assessment Committee's cost.

10988. (*Mr. Brace.*) But are you not laying too much stress upon the legislation as instanced by the Workmen's Compensation Act?—In the year 1897, when I had something to do with that Act in the House of Commons, I ventured to state that the profit upon coal in that year was 3d. per ton on the average, and that the cost of this Act would be 1d., and that it would therefore take away, if those profits remained, one-third of the profit made upon coal. I adhere to that view. Of course, latterly the profits have changed; they improved over three years; but it was a very serious blow at that time, and I only mention it because there may be other burdens of the same sort imposed.

10989. Yes, agreed, but it is possible to lay too much stress upon it. The Workmen's Compensation Act has not cost 1d. per ton for a very large number of important collieries. Of course, I am not speaking of your own collieries now?—I agree with you, but we are now busy with the fourth or the fifth year; every year, as you know, does not decrease the burthen, but you probably know it increases the burthen; with the permanent disablements at all my collieries, I find the cost is getting higher and higher each year. But I am not dwelling upon that.

10990. (*Chairman.*) Probably that increase will go on for 10 or 15 years?—Yes.

10991. (*Mr. Young.*) Was there not a prediction in the House of Commons as to the cost of the Workmen's Compensation Act, and was it not very generally stated to be about 3d. per ton?—I think I was one of the most active, I will not say opponents, but one of those who tried to make the Act more gentle in the burden it imposed, and I never mentioned more than 1d. I believe from Wales there was some evidence of a higher figure.

10992. (*Mr. Brace.*) And in Wales it has not cost a penny?—I do not know.

10993. (*Chairman.*) Are there any other obstacles to the coal trade which you desire to mention?—In the note I gave you I think I mentioned the question of the combinations of workmen. It is rather a delicate subject to deal with, of course. There is no doubt that the amalgamation of the workmen in very large numbers has helped to maintain wages at a higher level than they would otherwise have been. The rate now existing above the normal rate is higher in consequence of that combination.

10994. Could you tell us whether the improvements and the saving effected by all the application of brains, machinery, and so on which you have described have to any extent counteracted the advance in wages pure and simple? In other words, take one of your modern collieries, laid out in the best possible way, all the economical methods which can be suggested having been adopted. Is the cost per ton appreciably greater in such a colliery as compared with what it was 10 or 15 years ago?—May I answer it in this way? Put two collieries side by side, each paying as they are paying now, say 45 or 50 per cent. more than the normal figure.

10995. On the same basis of wages?—On the same basis of wages. The one owner has not the means, or has not the enterprise—one or the other—to adopt certain improvements; the other adopts every labour-saving appliance he possibly can put to work, having the capital, and so on; naturally that man has a distinct and substantial gain over his neighbour.

10996. Therefore with regard to what was rather indicated in Sir George Armytage's question, as to large areas being worked in one taking, larger pits being made, and all those facilities of labour-saving appliances giving their aid; will not those conditions to a certain extent counteract the increased amount of wages paid to the work people?—They do, to the extent that they are applied.

10997. You have experience of other businesses. Would you not say with regard to most businesses, although the wages paid to the individual workman are higher than they were 25 years ago, possibly, the cost per unit, whatever it may be—ton, yard, and so on—has not materially advanced?—I think it has materially advanced; not so much because of the question of wages *qua* wages—I mean as an exaction made by the working man—but partly owing to the conditions of working, the thickness of the seams, the distance of the workings away from the shaft; they all help to raise the cost.

10998. Do you mean legislative restriction as regards safety, and so on?—No, quite independently of legislation. If I work a seam say 6 ft. thick for 30 years, and then exhaust it, and come down to, say, three feet——

10999. Then you are not comparing like with like. You now, as I understand, are indicating that in the earlier days they worked that which was nearest, easiest, and cheapest; and now they are working not only at greater depths, but they are working probably seams which are not so economical per ton to work; and that therefore that is all tending, as I understand, to increased cost of coal?—Yes.

11000. And you would look in the future to not much reduction in the price of coal, I gather?—No, I think it will tend to increase.

11001. (*Mr. Brace.*) Has it not increased?—Well, obviously in the last three years it has, but it is going down again now.

11002. But is not the general average price of coal very much higher, taking the last five years, than the five years previously?—Yes, very much.

11003. (*Sir Lindsay Wood.*) Has not the shortening of the hours of labour had as much to do with the increased cost as probably any other item that is connected with it; that is to say, taking the present time and 10 or 15 years ago?—Yes, I should think it has had a good deal to do with it. Of course, as you very well know, that does not affect so much the question of the man who works the coal; he works by the piece.

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11004. I beg your pardon, I think it does?—He can work 7 hours, or 6½ hours, if he likes; but I thought your question rather referred to the man, who (after the getter), has to do with the coal, and whose hours are shortened; and, therefore, he restricts the man who cuts the coal.

11005. No, my point was as to the general shortening of hours, taking it that the men themselves get the same rate of wage?—Yes.

11006. But if the hours are shortened you have to employ a larger number of men in order to get the same output?—Yes, you have.

11007. Consequently, the cost upon that output must be very much enhanced by shortening the hours of labour?—Yes. Your conclusion is perfectly right, if you include every man throughout a colliery.

11008. (*Mr. Brace.*) Where have they shortened the hours of labour, say, for day workers, if you like, during the last 10 years?—I do not know. I do not follow the question of the hours quite so closely as Sir Lindsay Wood does in the North, because it does not come before me so constantly.

(*Mr. Brace.*) I know a very large coalfield where there has been no shortening of hours either for the day labourers or for the hewers of coal; so that it would not apply to that coalfield. I know of another coalfield where there has been shortening of hours.

11009. (*Professor Hull.*) Is there not one very important point bearing upon the evidence you have been giving about increased expense with regard to coal due to the larger initial outlay on plant and machinery—sinking shafts, and so on, to greater depths—and the loss of interest on that large amount of capital. If that capital was employed in some other way it would produce, say, 5 per cent. In the case of sinking pits, putting up machinery, and so on, there would be an enormous expense and outlay of money, say from £100,000 to £200,000. Then what would you consider to be a fair amount to lay by annually, either in the books or otherwise, towards recouping the owners of the colliery for their outlay, considering, I presume, that there would be a limit to the time in which the machinery and the plant could be employed for working out a certain district?—Well, that is a financial question entirely dependent upon the judgment of the investor.

11010. Yes, but it bears upon the question of increased cost of working and rise in the price of coal?—I had better give you my own habits and experience.

11011. Yes?—I would allow nothing whatever. I would put nothing whatever on one side for recouping the capital, because I think the best plan in managing a colliery, if you make money by working it, is to hand to your shareholders the money that is made, keeping back a sufficient reserve fund for emergencies. In the concerns I have to do with we never put aside any redemption sum in the way you suggest.

11012. Well, the shareholders are a unit, each one?—If you give a shareholder 5 per cent. one year and 20 per cent. another, and 15 per cent. another, he does what he likes with it; he calls part of it interest and part of it redemption, but we leave him to do what he thinks best.

11013. But do you not think it ought to be discounted by the sum of money necessary to recoup the original outlay which, once it is done with, is a dead loss, so to speak?—But that remark applies to every industry in the world in which you put your money. You put down £100,000, and you put it down because you think you will get it back with a certain rate of interest, and it is only because you think you will get it back that you put it down.

11014. (*Chairman.*) Could you answer this question with regard to the capital outlay? It is true that a large modern colliery requires a much larger command of capital to start operations; but take the case which you yourself have put, of a colliery the outlay upon which would probably be not far short of £300,000, which I think was the figure you mentioned, and which outlay would have to be expended practically before you began to earn anything, as I understand?—Yes.

11015. Now taking into account the output which you may reasonably hope to get by that expenditure, would the capital outlay in the first instance be much greater relatively to the production than it was in sinking, let us say, three smaller pits which cost only £100,000. I do not know whether I have made my question clear?—It depends, of course, upon what those £100,000 pits were sunk to do. Are you assuming one pit costing £100,000 to raise the same output as the one that would cost £300,000?

11016. No, on the contrary, I am assuming that it would not, and that is the point of my question?—But it might.

11017. I will put it in the other way: supposing that by your expenditure of £300,000 you are able to work and raise three times as much coal as by the expenditure of £100,000, the capital outlay relative to the production is no greater in the one case than in the other?—Certainly not; but my point was not that. My point was this, that where it required £150,000 25 years ago to be sunk upon a colliery in order to raise, say, 2,000 tons per day, it requires double that sum on the eastern line of England, or wherever you have deep mines to work in other counties, in order to provide the same output, for the double reason that first of all you have all the extra expense due to deeper sinking and heavier plant, and then you have the imperative necessity of putting the most modern and most costly machinery both as to banking and everything else——

11018. But, although it is costly, still it is economical?—But costing more. I thought we were discussing the question of capital outlay.

11019. I agree; the capital outlay is greater, but I wanted to see whether there was any additional charge per ton of coal upon the coal that is brought to the surface; because if, as I put it, you have a correspondingly large output, it does not matter whether you put your £300,000 into one, or divide it into three £100,000. I daresay it would be a little more, but not relatively very much more?—It is very difficult to indicate the precise percentage of increase that there would be, because it depends upon so many conditions.

11020. Quite so. It must be very well known, because there are hundreds of examples, I suppose, where the actual cost could be got?—I can give you a sort of illustration, which will be very familiar to Sir Lindsay Wood: in Durham 40 years ago there were collieries put down 250 yards deep which cost far more than a colliery now would in Yorkshire 600 yards deep.

11021. Quite so—because they had trouble with water, I suppose?—Yes.

11022. (*Professor Dixon.*) Under good conditions, and under modern conditions, if you had to double the depth of your shaft, and to double the length of your haulage roads, what increase in price would that give upon the coal?—Do you mean in the capital?

11023. No, not in the capital; it is in the running prices—the cost per ton.—Would you include in that case interest upon capital?

11024. Yes.—That would depend so much upon the capital you spend.

11025. I was taking the case of, say a shaft 1,500ft. deep and half mile haulage roads, and so on, and then an increase to 3,000ft. deep and a mile haulage?—It is a calculation I have not made.

11025*. I want to know apart from that the cost of haulage machinery?

(*Professor Hull.*) You probably would have to put up new machinery at greater cost.

11026. (*Professor Dixon.*) No, I am starting from the beginning?—If I put down a winding engine that costs £1,500 for 200 yards, I do not put down a winding engine that costs £3,000 for 400 yards, but a much higher figure. The cost of your plant does not increase equally with the depth you are sinking.

11027. Does it go up in a bigger ratio?—Yes. You want more boilers and more plant for producing steam, and there are greater difficulties the farther you go down.

11028. But would you say that, for instance, taking the depths of 1,500ft. and 3,000ft., it would more than double the initial price?—In winding engines and boilers, yes, but in other things not so much. In regard to other things, taking the ropes, say, the extra distance, would be a mere matter of arithmetic.

11029. (*Sir George Armytage.*) If you were to sink the existing shaft down to double its depth, the existing shaft itself might not be wide enough for the purpose?—Quite so. That would require very often either enlarging, or you may find the shaft so small that you would have to start a new one altogether, which is very often done in Staffordshire.

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Mr. Emerson Bainbridge.

25 Feb. 1903.

11030. (*Professor Dixon.*) I was taking the choice between the two, and not increasing the shaft, but making a new one with all the necessary machinery?—Yes.

11031. According to you, the cost price would be more than double for double the depth?—Yes.

11032. But the actual expense of running would be nothing like double, of course?—No. It would depend upon labour conditions, and general cost of working.

11033. Have you found wages higher for the coal-getters the deeper you go?—That would depend very much more upon the conditions of working underground than it would upon the question of depth.

11034. Yes, you have not found depth *per se* come in in the question of wages?—I should not like to say that I have, but I am working now no collieries more than 500 yards deep.

11035. (*Chairman.*) Then it does not come in?—No.

11036. There is a note in the statement you have handed in about the possibility of working coal at great depths. What do you mean by great depths—5,000ft.?—4,000ft. Some 25 years ago I gave a great deal of time to this question, and I wrote a paper for the Institution of Civil Engineers with regard to the possibility of working coal 4,000ft. deep. I was rather before my time then, but I tried to prove conclusively that it could be done, as regards the question of cooling the underground workings, by efficient ventilation.

11037. Well, we have examples now, have we not, very nearly up to that in actual working?—Yes, I think so—abroad. I do not know much about them.

11038. But you would not limit your views to 4,000ft. now?—No. At the time the difficulties of temperature, which I had tried to work out after taking every known case there was in the world at that moment, indicated to me that a strong enough mechanical power would be sufficient to make such deep working possible at a cost.

11039. May we take it that the main difficulty in your view would be temperature?—Yes, I think it would be, I think the mechanical question of working the coal will not be a serious one.

11040. But the power of ventilating the mines is much greater now, is it not?—Yes, I should say it is, decidedly.

11041. With regard to the knowledge and methods and so on?—Yes, but there is a much harder problem to be faced—a larger water gauge, for instance, and a bigger volume of air.

11042. Do you attach any importance to the depth in the sense of its having any effect upon the coal?—Certainly.

11043. Is there more crush?—Yes, decidedly more crush, but not so far as my experience goes such as to make it impossible to work.

11044. (*Professor Dixon.*) You would not alter your views, would you, with regard to the possibility of working to 4,000ft. deep? Modern workings confirm your view, I suppose you would say?—I think they have done so.

11045. Probably you would now go further than 4,000ft. The arguments you used, if I remember them rightly, would now apply to 5,000ft., or thereabouts?—Well, I daresay, allowing for the extra knowledge we now have of the power of mechanical ventilation, they probably would.

11046. (*Chairman.*) You see nothing at the present time to modify the view which you then took of the possibilities?—No.

11047. And I gather that we may even take a more hopeful view now?—I think an even greater depth will be worked to.

11048. What is the point with regard to amalgamation which you had in your mind? Does it mean amalgamation of all collieries?—It was partly that I thought it right to consider, so far as I could, any point that there might be in favour of prolonging a good condition of the coal trade, and I thought I would place before the Commission the view that there would be an advantage in the joining together of collieries more than has taken place, with the object of decreasing competition and lowering the expense of administration. I think if one may take an illustration, for instance, in London at the present moment—this is rather a separate argument—I am not wrong in stating that there is £500,000 paid every year in interest upon capital sunk in the trade of the coal merchant—the man who acts between the consumer and the producer. Well, I take it that under a more enlightened system of co-operation a great deal of that expense would be saved, and that if one could learn the art of avoiding competition, and join together a number of interests, and sell direct to the consumer, the consumer, the producer, and the colliery proprietor might all share in the benefit.

11049. But the coal merchant has already taken that step to a considerable extent, has he not?—He has.

11050. And is he not also in some cases a colliery owner?—Well, I do not know. I suppose many of them are colliery owners, but I cannot speak positively.

11051. However, you think there might be possible economies effected?—I am only throwing that out as being one mode of putting some of the money, which is now got by the coal merchant, into the pocket of the producer, the consumer, the workman, and the railway company.

11052. How would you answer this question: Supposing you amalgamated half a dozen collieries of varying standards of efficiency and of economy in working, would the tendency be to lower the whole standard or to raise the whole standard—to lower it towards the average or to raise it towards the maximum?—Their efficiency, and the manner in which they take advantage of their combination, will depend very much upon the amount of prudence and general administrative power at the head of affairs.

11053. Is not the tendency of all associations rather to raise the standard to the maximum than to lower it to the minimum?—My own feeling would be certainly that as a rule, putting all the heads together, the most efficient man would rule, and would raise the rest to some extent to his standard, as you find it on most boards of directors.

(*Mr. J. S. Dixon.*) If a combination such as that found one colliery paying and another losing, I fancy the tendency would be to inquire why the one was losing, and to compare the two, and to bring up the one which was lagging behind to the standard of the one which was making money.

11054. (*Chairman.*) That is precisely what I meant, but I did not put it so well?—Yes, that is one of the great objects of combination. You have six managers whom the head manager calls together, and he rubs them all together, and he says "I want to get an idea from one to apply to the others, and so you get ideas all round.

11055. You have not said anything about the increasing profitableness of the colliery business by such things as washing the inferior and dirty coal, and so on. Is there any washing done in your part of the world?—Yes, I am washing upon a very large scale.

11056. Is it good in effect?—Yes, but it does not quite work in the way your question indicates. It has not been done so much for the purpose of making profit, as to make unsaleable coal saleable.

11057. Is that not the same thing?—Well, I might have saleable coal that I could improve very much by washing.

11058. Do you not get rather more than the cost of washing?—I will put it in another way. I have been driven to wash against my will.

11059. Perhaps that is only because you were so conservative that you did not adopt the most modern methods, or if you had been more greedy of profit you would have adopted that plan earlier?—Let me endeavour to put it a little more clearly; in a case where the small coal is so impure that when made into coke your customers will not buy the coke, that is a case in point where we are driven to adopt washing machinery

11060. But that is really an improvement of the article?—Of course it is.

11061. That is increasing its value?—I am endeavouring to make a distinction in your mind between the case of the colliery proprietor who is obliged to do what I have indicated to you, and that of one who need not do so, but does it in order to make more profit. Now, if I take my nuts which I can sell without washing them, and I wash them in order to make them more saleable—that is a thing which I need not do unless I like—I can go on selling them, but I can make them

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more saleable by washing the dirt out of them. That is one line of conduct with regard to washing. The other is the case where I must either stop my coke ovens or erect washing machinery.

11062. Yes; but I understand you would stop your coke ovens, because without the washing you would make a coke which is inferior?—Unsaleable.

11063. And unsaleable because it is inferior?—Yes.

11064. Not only that, but I put it higher than that, that it is not only more saleable, but that it is more valuable for the purposes to which it is applied?—Of course.

11065. Therefore it is more economical for a man to pay the additional price for something which produces the result in a better manner than it would be to use the inferior article?—Yes, I do not think I have made myself clear. I agree with all that, but I was pointing out that in certain cases a man may put down washing machinery when he can do without it, but where the application improves his profits; and there are other cases where he cannot carry on without washing machinery.

11066. I agree—Of course the remark also applies to the careful sorting of coal. At one of my collieries we have taken a great deal of trouble with that, and there is no doubt that we get a substantially extra price through a costly way of dividing our coal into various sizes, and making those sizes well thought of and well known in the market.

11067. You have, of course, great experience, not only in your own particular coalfield, but in others; looking back into the past, would you say that as regards the avoidable waste in working, the principal collieries to-day are working efficiently. Is there much waste?—Do you mean underground?

11068. Yes—In cases where mines are worked as they are worked in the Midland Counties, there is very little scope for waste, because you pay for the coal by the acre, and you have to pay for the acre of coal whether you work it or not; I mean to say you can waste 50 tons if you like to the acre, or 100 tons or 1,000 tons; but you have to pay for it. That is a very strong incentive to the ordinary colliery proprietor to avoid all waste that he can. In other parts of the country, in the North of England, they pay by the ton; I am not quite sure about Scotland. It is a question very much of the way in which the manager himself works his mine and the way in which the lessor's agent looks after him.

11069. I am afraid I have not made my question clear. Given that you have a seam of coal of such and such a thickness, weighing so much, and representing so many tons, if you like, to the acre; are those tons obtained, or are there any causes or influences at work by which what we may call the available resources are not brought to the surface and made available to the public?—In the case of the collieries which I have to handle there is no waste at all.

11070. Practically all the coal is brought out, is it?—It is all brought out.

11071. We had some evidence from your part of the world, which indicated that in some of the seams, for example, either because the coal was of inferior quality, or because the seam was very thick, both top and bottom were left?—Yes.

11072. You do not know of cases of that kind?—I know of cases of that sort, but they are generally where the top and bottom are inferior; I mean to say, the man who works the coal says to himself, "I am going to work this coal to the very best advantage; if I can make a little more money by working out 7ft. than I can by working out 5ft. I will bring it out"; but if the top part is so inferior (as it is in certain parts of South Nottinghamshire) that it is better to leave it in, it is left in.

11073. (*Professor Lapworth.*) But that coal is left behind for ever and lost to the nation?—Yes, and it is coal the working of which would bring down the margin of profit upon the whole.

11074. But still it is a national asset which has been left behind in the ground?—Yes.

11075. (*Mr. Sopwith.*) It is not always left entirely; there are some cases where you leave the roof coal up so thick that it would be workable at some future time: for instance, the culm over the top hard—you know that?—I know it well. I should think there is a very remote chance of the culm coal ever being worked again.

11076. Well, not according to our present ideas?—It is there.

11077. Yes, it is there, and it is sufficiently thick?—Well, barely. In certain cases it varies from 1ft. to 3ft.

(*Mr. Sopwith.*) But there are large areas where it is left up, and where it is nearly 3ft. thick, and it might be worked at some future date.

11078. (*Mr. J. S. Dixon.*) Is it broken up—that is the question?—It is certainly damaged, and sometimes broken badly. It is so near the other seam which Mr. Sopwith refers to that it must be broken.

11079. It is worked long-wall?—Yes.

11080. (*Professor Lapworth.*) Supposing coal were at twice the price it is now, would the seams left behind be worked?—Well, let me give you an illustration in order to answer that question. I was working a seam two years ago 2ft. 4in. thick, and I could make a profit upon it; I went on working it until it came down to a loss of 1d., and then I stopped. If that selling price had gone on until now, I should have been working it still.

11081. Yes, exactly; it depends upon the price of the coal as to whether the material is left behind?—That must be the ruling factor. A man would be foolish to go on working perpetually when he was losing; he would not go on any longer than he could help.

11082. That is true, but still this coal at a high price would have been available for the use of the nation, but being at a low price it is left behind and wasted. That is the point we wish to get at?—Yes, that is so.

11083. (*Sir Lindsay Wood.*) I think your evidence goes to show that the chief difficulty in increasing the number of coal-cutters that are used is due to the condition of the thill and the roof?—Yes, and in some cases to the inability of the colliery proprietor to find the capital to lay down machinery.

11084. But I do not go quite so far as you do as to the difficulty in finding capital. In the event of the capital being raised, the chief difficulty is the roof and the thill?—I have only ventured to point out what I think restricts the application of coal-cutting machinery. I have a very strong feeling as to the capital question. But the other matter, as you say, is the roof—the thill, the part where it is holed—being soft or hard, and the tendency of the coal to tumble down. In Derbyshire, I laid out a large colliery to work entirely by machinery, and I had to abandon it; we cannot apply a single machine.

11085. But is not the advantage in the use of machinery chiefly obtained where the coal is hard?—That is what I wish to say: the harder the holing is, the more advantage with the machine.

11086. Therefore, in the case you are referring to, probably the coal is so soft that you could work as much by hand as you could by machine?—Pretty nearly.

11087. Therefore the machines were practically no good?—No good at all.

11088. But where it is hard and thin there is a great advantage in using machines provided the seams are otherwise suitable?—The harder the cutting point, and the thinner the seam, the greater the margin of saving by the application of machinery.

11089. Have you had any experience in using electricity in coal-cutting?—No. I should always avoid using it where I had a gassy mine.

11090. On account of the fear of fire——?—Well, it would be a remote risk which I would not like to run; I would rather go on using air. I do not wish to labour the question of capital, Sir Lindsay, but I would like to point out that my first coal-cutting machinery experience was with you some 35 years ago, and the fact that it has developed so slowly since rather confirms what I say; you were cutting coal 35 years ago at Hetton, and I was there.

11091. I do not think it was a question of the capital that stopped us?—No, not there, but elsewhere.

11092. It was a question of the nature of the roof, and not being able to work long-wall?—Yes, there it was so.

11093. We found a difficulty in working long-wall, and we stopped?—Yes.

11094. (*Mr. Brace.*) What is the proportionate increase in the value of coal per ton between washed and unwashed coal?—It would depend very much upon the

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Mr. Emerson Bainbridge.

25 Feb. 1903.

quantity of dirt there was in the unwashed coal. It is a very difficult question to answer. You have one coal which is very impure, and another which is partly impure. I should think it would vary from 1d. to 1s.

11095. Where it would be, say, 6d., it would pay well to wash?—Well, that would depend upon the outlay for the machinery and the cost of working the machine which is about 6d. per ton.

11096. It was given yesterday at 1½d., I think?—I do not confirm that figure.

(*Mr. J. S. Dixon.*) That was the figure for wages.

11097. (*Mr. Brace.*) There would be increased labour, I suppose. You say you think it is 6d. a ton?—I think 6d. would be a very true estimate of the cost of washing. You have so many things besides the labour of washing; you have to carry the dirt away and dispose of that, you have to deal with your settling ponds, the wear and tear of the machinery, the fuel for driving the engine and pumping the water to the washing machine.

11098. You say you have closed three collieries recently?—Yes.

11099. Were they old collieries?—No, they were new ones.

11100. How deep were they?—One was a drift, another was about 250 yards deep, and the third 300 yards deep. That is the case I mentioned to Professor Lapworth, where the seam was thin, and under conditions of high prices it paid to work.

11101. That is the very point I was coming to, that there are seams of coal which can be worked at a profit when prices are good, and which are closed naturally as soon as the turn of the tide comes?—Yes, obviously.

11102. Many collieries have been lying idle, and as soon as a boom in the trade arrives, as it has arrived during the last two or three years, they open again, and as soon as the boom has passed they close. Those would not be normal conditions?—No, I did not say anything about normal conditions.

11103. I agree, but you said you had closed three collieries?—I closed them because of the change in the conditions.

11104. But were it not for the boom they would not have been opened at all, possibly?—I do not think they would.

11105. (*Mr. Bell.*) I should like to ask you one question upon the cost of getting coal, comparing like with like. I think you do not quite agree that the improved condition of mechanical appliances for getting coal compensates altogether for the extra cost of getting it now as compared with previous years?—I think if you had the capacity and the power of always applying those conditions—you are rather assuming that everybody can apply the most modern plant. Is that the assumption?

11106. Well, you illustrated from your memory a case in which you were getting coal in the county of Durham for half-a-crown per ton?—Yes.

11107. That would be, of course, under the best conditions of mining in those days?—The very best.

11108. Supposing you had that seam of coal now, and supposing you had a colliery equipped with the latest conditions of to-day, can you give a figure of the difference in cost of winning that seam to-day as compared with what it was at that time—35 years ago?—I am afraid that would be very difficult for me to answer. I should think it would be higher.

11109. You have no idea as to how much?—It would be higher, because of the general value of labour being higher.

11110. Yes, all things considered, including taxes and legislative conditions?—Yes. You see this was a peculiar case where no machinery was required, and where drifts into the hillside were all that existed. There was no interest upon capital there. That condition does not reign any longer.

11111. Supposing there were many pits working coal under very favourable conditions with regard to the getting of coal, and supposing you were to compare similar conditions existing to-day, could you give a figure as to the extra cost of winning now as compared with then?—I am afraid not.

11112. But would you go the length of saying that it would be substantially higher?—Yes.

11113. One never hears of anything so low as half a crown per ton now, even with a drift?—No.

11114. 50 per cent. addition would make it 3s. 6d. or more?—I question whether there is any cost anywhere under 5s. 6d. There may be in the north—I do not know.

11115. Yes, but that additional cost is for a different condition of coal and seam?—Yes, under more modern and less promising conditions.

11116. You would not like to give a figure as to the additional percentage of cost in getting coal to-day of similar thickness and out of similar seams?—No.

11117. (*Mr. Sopwith.*) With respect to the working of coal by machinery, do you work by the day generally or by contract?—By the piece.

11118. You have skilled men at the machines, and then you have the getters who follow them up, and the fillers?—Yes.

11119. The getters would share in the proportion of the extra advantage which is gained by machine, would they not?—Different conditions prevail in different collieries. Sometimes it is done jointly and sometimes separately, and sometimes one man takes a contract for a number of machines.

11120. You put it that the filler would be in the same position as he would be in if he was working by hand; but would not the natural tendency be that he would get some slight increase?—The tendency would be in that direction.

11121. Is the filler paid by piecework?—Very generally he is paid by the day.

11122. Separately—they are not included in the contract?—Sometimes they are paid by the day and occasionally by the piece. We have so many different varieties that it is very difficult to answer that question.

11123. (*Chairman.*) The real point with regard to it is that if he were paid by the piece the presumption is he would have more coal to fill?—Yes. My answer is that sometimes they are paid by the day and sometimes by the piece.

11124. (*Mr. Sopwith.*) So that the tendency would be to benefit everyone all round—even the unskilled labourer?—Yes, the tendency would be to benefit all.

11125. You were saying with respect to a certain coal, that it probably would not be worked; but do you not think that if you had a 3ft. seam which was left in the gob because it was of a slightly inferior nature, and there were not many wastes left, and supposing that it was almost within range of being worked at the present time, and still a matter of 6d. per ton prejudiced it so much that it could not be worked, would you think that it would not be likely to be worked in the future?—If it were a coal seam that had been left over another coal seam and the proprietor knew that the upper seam was probably damaged by the old working of the under seam, I think he would go to an inferior seam in some other part of the colliery before he would tackle a damaged seam of that character.

11126. Have you ever had any experience of working a seam after the lower part has been worked out?—Yes, we are doing it now in Warwickshire.

11127. Within a short distance?—Yes.

11128. And you have been able to get that coal out?—Yes, that is in the case where we have a fairly thick seam, about 5ft. thick, overlying a seam of 6ft. thick. We can then work it.

11129. You have not tried to work a thin coal over another?—No.

11130. I have tried it myself in some cases, but I admit at the present time it is not profitable. But in working coal which is practically either roof coal or separated by a distance, it does not appear to be broken so much as one would expect, and the only thing which would prejudice it is the leaving of the wastes and so many open spaces. But if you have a large distance in the roads it seems to be quite feasible that it would be worked at some future time?—I agree there might be conditions under which it would be possible to work it to advantage, but it would depend altogether upon conditions. Besides the question of the condition of the seam upon which you go to work, there is the point of the margin of profit on selling price available at that moment.

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11131. I only want to get rid of the idea that the roof coal is something which is necessarily lost, because I do not think it is?—No, I would not say that.

11132. (*Mr. Teall.*) I think you would favour any change that would increase the output of coal to the country which would improve the coal trade. What I mean is this: you would not favour any restriction on the output of coal, regarding coal as national capital?—Are you referring to the export of coal?

11133. No, I was thinking that supposing there was reason to believe that the coal supplies would be exhausted in a comparatively limited period, would you still say that the coal trade should be encouraged in every possible way rather than that we should have an eye to posterity, so to speak?—Well, I should answer that question in this way, that if I am raising, as I am just now in one particular case, 2,500 tons of coal per day, and shipping 1,500 tons of it, and having no other market than shipping, if you restrict me from shipping I cannot carry on the colliery. Therefore, for the mere purpose of maintaining the coal trade and enabling both the producer and the workman to go on, it would be an act of great unwisdom, I think, to arrest the exports. Then I may add this: the time for the exhaustion of our coalfields, I think, is sufficiently far distant to make it safe to rely upon the various modes of economy of fuel which are constantly being developed. I am hoping in my next colliery to bring down the consumption to half the figure I have had in the past by adopting various improvements, by means of gas engines and electricity; if those improvements go on, I think, there is every reason to disabuse one's mind of the danger of the exhaustion of the coalfields, especially in view also of the possibility of the means of using oil—crude petroleum—being developed by importation.

11134. You have therefore some figure in your mind as to the duration of the coalfields which you are most familiar with?—Well, I remember that of the last Commission, which gave us a good long time.

11135. But you have no figure derived from your own knowledge of the coalfields and the present demand for coal?—I am working now a number of collieries that must last 100 years, and that makes me easy, as I think they are fairly typical of a large number of other collieries, many of which are still unopened.

11136. (*Chairman.*) With reference to what Mr. Teall says, I should like to ask one question: compared with the previous Commission, which is clearly in your mind, would you say that to-day the view would be that coal exists in fields and districts which were not acknowledged on the previous occasion?—That is a matter which you are having very carefully investigated, I suppose.

11137. It is, and I want a competent opinion upon it; that is the object of asking the question. Bringing it home to a district which you know very well, with your knowledge to-day and looking back, if you can contemplate such a thing, to your knowledge in the sixties, would you put the verge of the coalfield a little further towards Gainsborough now than you did then?—I do not want you to attach any value to the opinion I may express, because I have not gone sufficiently into it, but I do say this, that at the time of the last Commission the whole matter was gone into so extremely carefully and exhaustively, that I think the amount of coal available which your Commission will find will be very little in excess of what was thought to exist then. That is my own feeling.

11138. Within your own knowledge you could not point to any coalfield which has now been proved, which was excluded as being unlikely by the previous Commission?—I have one place in my mind which I am sure will be in yours, as you ask the question, namely, that case in Lincolnshire where a borehole was put down, and I cannot tell you off-hand how far that particular borehole lies to the east of the line which the Commission laid down in their report.

11139. (*Professor Lapworth.*) I think it lies within that line?—I should have thought it did—that they would have said to themselves: "In all probability coal will extend as far as the Scarle borehole." If so, it rather confirms what I was venturing to submit just now. They went into the matter so fully that they believed at the time there would be coal there, and the borehole has proved that they were right.

11140. (*Mr. Young.*) I should like to go a little further into the question put to you by Mr. Teall; you do not think it would be advisable to restrict the export of coal, because I presume such a course might at once bring about a condition of things which would entail suffering upon a considerable number of people, which would only be brought about in the natural course of events some 400 or 500 years afterwards, if the coal be exported. Is that so?—I did not mention 400 or 500 years. *Mr. Emerson Bainbridge.* 25 Feb. 1903.

11141. At any rate, ceasing to export now would bring about the same condition of things that would arrive then, if no substitute had then been found for the coal we export now?—The stopping of the export now or even the arresting of the export now would be a very serious thing to those collieries which are on the coast in Wales, Northumberland, Durham, and Yorkshire.

11142. You think that the tendency during the last few years has been for the cost of getting coal to increase?—Very much so. The Union officials have spent a good deal of time in the interests of their clients in watching every colliery in various districts in the Midlands, and they are constantly raising the wages paid to one and to another; that is, independently of all the district rises; and it has had the effect of raising the cost all round, I should think, from 1d. to 3d. per ton.

11143. Do you think that that has placed us at a disadvantage with other coal-producing countries?—I do not know what has been going on in them in the same direction, but I should think it has to a small degree. It is just possible that their men may have been working on the same lines. I am not familiar with what goes on in America and Germany in that respect. If they have all been doing the same, it has kept us all level.

11144. Yes, I think that is everything upon this point. It is a question of what is the relative position compared with them. In your opinion what is the return upon capital during the last 10 years, compared with the return in the previous 10 years; or, if 10 years is not sufficient, take 15 years, compared with the preceding 15 years?—In coal mines?

11145. Yes.—I do not think I can give you an answer to that question. If you ask me what my own collieries have done in the last 10 years, compared with the previous 15 years, I can tell you. The previous 15 years just includes the 1873 period. There have only been two such periods of high prices in the last 30 years: one was in 1872-73 and the other in 1900-1; and in 1882-3 there was a less substantial rise. Those are the periods of high prices that have taken place.

11146. Yes, and 1890-1?—Yes, that was not very much.

11147. Again, in 1899, 1900, and 1901?—Yes, but the two ends of the period are the two most important—1872-3 and 1900-1. Now, I think your question is, which period of 15 years?

11148. Yes—I should think, including the 1872-3 period, they have all been about the same.

11149. Therefore, the increased cost has not placed us at a disadvantage so far, compared with the earning power of capital?—But that is entirely due to the special spurt we had two years ago.

11150. And the special spurt we had in 1872 and 1873. But these come in cycles, do they not?—Not necessarily. They have done so.

11151. We can only speculate from past experience?—Yes, that is all.

11152. We have had that every 8 or 10 years?—Yes some slight and some substantial advances.

11153. (*Mr. J. S. Dixon.*) You have had considerable experience in coal-cutting machinery. What thickness of seams are you operating on?—From 2ft. 4in. to 5ft.

11154. Do you find the advantage greatest in the thinner seams or the thicker ones?—It is greater in the thinner.

11155. I think I may take it from your evidence that generally you consider the cost of working from every cause has increased during the last 15 years?—I do

11156. Considerably?—Yes.

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Mr. Emerson Bainbridge.

25 Feb. 1903.

11157. Do you consider that by the use of coal-cutting machines and other labour-saving appliances the cost may be brought down to something approaching what it was some time ago?—No, I do not, because I do not think there is much scope for the development of coal-cutting. The conditions which Sir Lindsay Wood asked me about which are favourable to coal-cutting are so limited.

11158. So that you expect a permanent increase in the cost of the production of coal?—Yes; I do not think you will arrest that by the application of coal-cutting machinery, not because coal-cutting machinery would not do it, but because there are not the peculiar physical conditions which allow the scope for coal-cutting machinery here that I believe there are in America.

11159. We are to contemplate, then, that we are going to have a permanently more costly coal than previously?—Yes, I should think so.

11160. Then, with regard to the tendency to adopt improvements, is there not a considerable desire on the part of gentlemen like yourself, and colliery officials generally, to go about and inspect and adopt the best appliances they can find?—I think there has always been, but there has not been the same capacity for adopting them in the past that there has been in the last few years.

11161. That is largely because of the Mining Institutes in different parts of the country devoting themselves to the subject, so that these improved appliances have become known and discussed amongst the members?—There is nothing new in that. According to my experience, the Mining Institutes have always done that

11162. But there is a general tendency towards improvement in the appliances of colliery working?—Yes. I should not like to say that there has been a great development of the mining engineer's mind. I think he has always had the idea to adopt the best thing, if he had the money to spend upon it.

11163. I think Mr. Bell put the question of cost in a very fair way, if you could have answered it, taking the seam from which you produced coal at 2s. 6d. per ton. Assuming that that seam of coal started to-morrow under all the same conditions, supposing that field had not been worked out 50 years ago, you cannot say what it would cost to-day?—No, that is a question I declined to answer, because I did not feel capable of making an estimate.

11164. With regard to that, wages would probably be 40 per cent. more to-day than they were then?—Quite.

11165. And other costs would be more?—Yes; machinery would be more expensive also.

11166. But there would be no machinery; I am supposing you had this drift to start with?—Yes.

11167. Other costs would be increased also, such as expense for materials and furnishing of all kinds?—Take, for instance, the rent; the rent of that coal would be 8d. per ton now, and I believe it was about 2d. then.

11168. Exactly. Taking 40 per cent. rise in wages, and the increase in royalty and the increase in furnishings, and so on, it appears now it would probably cost 70 per cent. or 80 per cent. more, at any rate?—It would be substantially higher.

11169. (*Dr. Le Neve Foster.*) Did I understand you to say that you abandoned coal-cutting machines in some cases because the coal fell over?—Yes.

11170. What thickness of seam was that?—A 6ft. seam. It was partly because of that and partly because the holing was so peculiarly adaptable for hand-holing.

11171. For two reasons?—Yes.

11172. Do you know of any coal-cutting machines of the pneumatic chisel type which are at work anywhere?—Yes, I have tried them.

11173. Did they answer?—No. We could not get the workmen to go on using them. You mean, of course, the Jeffrey—the one you hold by two handles with the chisel working in the coal.

11174. No, I did not mean that. I refer to a machine of the type of a caulking hammer?—Yes, it is the same thing.

11175. I do not mean the punching machine. Some punching machines are different?—Is it not a machine in which the man sits upon the ground, holding two handles, and has the drill working percussively in the coal?

11176. No, I am not talking about that one. I am speaking of a much lighter machine, working upon the principle of a caulking hammer?—Could you give me the name of it?

11177. They have been using it at the Mansfeld Copper Shale Mines—quite a light machine?—I have not seen it.

11178. They have also tried one at the Lanemark Collieries, in Scotland?—I have not heard of them.

11179. Then with regard to the Stanley machine, you say it cannot be used in strata other than coal, or strata of equal softness?—I do not think I said that. I said it is not applicable in the same way to stone. I meant by that that if you had a very soft stone to drive through, like chalk, I dare say it would cut that.

11180. But does not Stanley profess to make a machine that will work in stone?—I have not heard so.

11181. Is not the diameter of the tunnel that you cut about 5ft.?—Yes, about 5ft.

11182. Then if you are working a seam 4ft. thick, you have to cut away a certain amount of stone?—No, you can have a machine made to cut 4ft. Stanley makes a machine to cut that.

11183. Then if you have a 4ft. seam you are using a 4ft. machine?—Yes. I did that in a case in which I tried it in a 4ft. seam. We might have had a 5ft. machine if the strata above or below were sufficiently mild to be cut by the machine.

11184. With regard to syndicates for selling coal, has not the Liège syndicate proved a success in Belgium?—I do not know.

11185. With regard to washing we have heard some evidence about foreign machinery being copied in this country. Is it not the fact that English washing machinery has been sent over to large collieries in the north of France for washing purposes?—Well, I happen to be the chairman of the company which sends it out, so that perhaps I had better not dwell upon that; but it is the fact.

11186. It is a fact that French people have been obtaining washing machinery from this country?—Yes, very largely.

11187. It did not seem to be known yesterday when the question was asked. You were talking about selling a good many varieties of coal. How many varieties of coal do you make in sizing and screening?—It depends entirely upon the coal; in one coal we may have three and in the other we may have eight. I should put those down as the two limits.

11188. And you find it an advantage commercially in making those sizes?—Yes, very much so.

11189. With regard to bad coal being left, what do you call the limit of badness at the present time—with regard to ash, we will say?—That would depend very much upon the quality of the coal in which the ash was. You may have a very good coal with 11 per cent. of ash.

11190. Quite so, but in the coal that you say you are washing at the present time, what would be the amount of ash?—That hardly applies, because in that case all the dirt congregates for the most part in the small coal which you place in the washing machine, and I should think in some cases the quantity of dirt would amount to 16 per cent., partly due to careless filling of the coal in the mine, and partly due to the natural dirt in the coal.

11191. Then another point with regard to statistics: do you think it would be difficult for a colliery company to state in the annual return the purpose for which the coal was going to be used in a general way?—Will you put the case a little more specifically?

11192. For domestic purposes, gas-making, and steam coal?—I do not think it would be very difficult. If you ask me to-day the proportions of coal which I sell in those different directions I should be able to tell you. In some cases a merchant would not say what he wanted the coal for; he might buy the coal, and you would not know whether it was sold for gas, house, or steam. In Yorkshire, you see, the steam coal happens to be applicable to all three purposes. The Park Gate Seam happens to be sold for all three—steam, house, and gas. How could the colliery proprietor say what

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it was used for? He could if he happened to have a contract with a railway company for one supply, and with a gas company for another, but if a merchant buys from him he could not know.

11193. But he could in some instances?—Yes, approximately.

11194. Would he have any objection, do you think, to giving that information? Would you have any objection to giving your statistics, provided the name of your colliery were not published?—I should have an objection to adding any more to the clerical work of my staff in giving statistics of any kind, but otherwise I would endeavour to oblige if I were asked.

11195. With regard to the coal resources of the kingdom or the length of time they will last, you said that petroleum might be introduced? Is it not much better for us to burn coal than to buy petroleum?—Are you speaking to me now as a consumer or as a producer?

11196. No, as an Englishman?—Well, the duty of a man who, for example, carries you on a railway is to carry you as cheaply as he can, and if he can buy petroleum from Texas cheaper than he can buy my coal, I think it is his duty to do it. Of course, I would do my very best to prevent him.

11197. Do you know anything about the use of coal in the form of dust for firing boilers?—You mean impalpable dust?

11198. Yes?—I knew something of Crampton's application of it, which seems to have been very little developed, and also that of another man who is dead—I forget his name now. I have never tried it.

11199. (*Professor Dixon.*) In working the Stanley machine for driving a drift, were you using compressed air or electricity?—Compressed air. *Mr. Emerson Bainbridge.* 25 Feb. 1903.

11200. Did you notice much cooling effect in the air?—Yes.

11201. It made a considerable difference?—Well, it is not a hot mine, but the machine certainly has a cooling effect. In a hot mine it would be a very useful machine to use for that reason.

11202. I suppose most of the actual coal-cutting machines that you are using in the long-wall are worked by electricity, and not by air?—I think most of them are worked by air, as a matter of fact.

11203. Do you find much difference made in the ventilation along the long-wall?—Not very much; there is always a slight improvement.

11204. That is, I suppose, in case there should be any gas?—A well-ventilated mine should not depend upon the coal-cutting machinery.

11205. No; of course, my question had really reference to very deep mining, and the difference it would make in such cases?—In very deep mining there is no doubt that the deeper and the hotter the mine, the more marked would the effect of the machine be.

11206. Have you had any difficulty with electric cables? How do you fasten them?—I do not know; that is a matter of detail which I have not gone into.

Professor PETER PHILLIPS BEDSON, M.A., D.SC., called; and Examined.

11207. (*Sir George Armytage.*) You are a Fellow of the Chemical Societies of London and Berlin, and Professor of Chemistry at the Durham College of Science, Newcastle-upon Tyne?—Yes.

11208. Will you kindly give us your statement?—For the past 20 years I have taken an interest in the question of the manufacture of coke from coal, and have from time to time visited works for the purpose of inspecting different methods employed. In the evidence I submit, I prefer to approach the subject entirely from the chemical standpoint as to the economies that are obtainable in the manufacture of coke. The production of coke in coke ovens without the utilisation of waste gases beyond the employment of the heat produced by their combustion for the purpose of the carbonisation of the coal, is not only an uneconomical method of using coal, but is also to be discouraged, because it adds to the proportion of solid matter floating in our atmosphere.

11209. In other words, you mean that by coking it you do away with smoke, and so forth?—I mean that this method of coking is a dirty method, and of course produces smoke; it is uneconomical because of its waste. Coke manufactured in this manner from a coal yielding, say, 60 per cent. of coke, is obtained at the expense of 43 per cent. of the heat value of the coal.

11210. Now as regards the method of coking in ovens built in series back to back?—Of course that is an improvement in the direction of the more complete utilisation of coal. To form some opinion of the extent of this improvement, I have taken the information and data published first by Mr. A. L. Steavenson of Durham in the year 1877, where he gives an account of the working of plant at a colliery in the county of Durham. From this it would appear that the waste gases used under boilers evaporated 0·87 ton of water per ton of coal coked. This would show the cost of coking to be 37·8 per cent. of the heat value of the coal. The yield of coke in this case was also 60 per cent.

11211. That was in 1877?—Yes, in 1877, and quite recently Mr. M. R. Kirby has given an account of a series of tests made with a similar plant at three collieries, also in the county of Durham, one of these being a colliery to which Mr. Steavenson refers. In this case the water evaporated by the waste gases is given as 1·3 tons per ton of coal carbonised. *Professor Peter Phillips Bedson, M.A., D.Sc.* 25 Feb. 1903.

11212. As against 0·87?—Yes, as against 0·87. It is an improvement, of course, to some extent.

11213. That is in 25 years?—From the data supplied in the paper I calculate that the coke has been obtained at a cost of 36 per cent. of the total heat value of the coal. The yield of coke in this case is again 60 per cent.

11214. Then the yield of coke appears to be 60 per cent. in all these cases?—I have taken this as an average yield, but in Mr. Steavenson's paper 60 per cent. is the figure given, and also in Mr. Kirby's paper it is given as 60 per cent.

11215. The difference being that during the period from 1877 to the present time it has been done with very much less heat. Is that not so?—Yes; in 1877 it was 37·8 per cent., and in this year it is 36 per cent.; that is the only difference. It is a question, I believe, very largely of boilers and boiler flues.

11216. (*Sir Lindsay Wood.*) You mean the construction?—The construction of the boiler.

11217. (*Sir George Armytage.*) Then with regard to the treatment of the coal in the retort coke oven?—The retort coke oven with plant for the recovery of bye-products is a much greater advance toward the complete utilisation of the coal, both materially and thermally. The treatment of coal in the retort oven yields: (1) a larger proportion of coke; (2) bye-products in the form of ammonia and tar; (3) gases which can be more readily controlled; (4) waste heat which can be utilised for steam raising; (5) surplus gas available for steam production, or for power, or one might add for illuminating purposes. These are all obtainable with a smaller expenditure of the heat value of the coal than in the ordinary oven.

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Professor Peter Phillips Bedson, M.A., D.Sc.

25 Feb. 1903.

11218. The Beehive?—Yes. To institute a comparison between these different systems, I have taken the data published of tests of the working of the several methods of coking coal, and from these have calculated a heat balance-sheet, expressed in terms of the water-evaporative power of the coal, coke and gases produced in the carbonisation of coal. These are contained in the following tables which I have prepared :—

1. Thermal Comparison of different Coke-Ovens.

	A.	B.	C.	D.
One ton of coal yields - Coke	6	·6	·6	·75
One ton of coal yields - Gas	·4	·4	·4	·25
Tons of water evaporated per ton of coal	15	15	15	15
Tons of water evaporated by the coke	8·5	8·5	8·3	10·5
Possible evaporative power of the volatile portion of the coal.	6·5	6·5	6·7	4·5
Steam raised by waste heat in tons per ton of coal	–	0·87	1·3	1·2
Heat used to coke the coal, including loss in chimney and radiation, expressed in tons of water evaporated.	6·5	5·63	5·4	1·5
Surplus available heat	None.	None.	None.	Gas = ·66 tons of water evaporated.
Bye products	None.	None.	None.	Tar and ammonia = 1·14 tons of water evaporated.

II. Total heat-value of Coal = 100.

	A.	B.	C.	D.
Coke	56·6	56·6	55·3	70
Waste heat utilised	–	5·8	8·6	8
Heat used in coking including loss by chimney, radiation, &c.	43·4	37·5	36·0	10
Surplus as gas	None.	None.	None.	4·4
Represented by tar and ammonia	None.	None.	None.	7·6
	100	100	100	100

III. Heat employed to produce one ton of Coke expressed in amounts equivalent to tons of water evaporated.

	A.	B.	C.	D.
Tons of water evaporated	10·8	9·4	9	2

A. = Bee Hive.

B. = Bee Hive. (Iron and Steel Institute Journal, 1877). A. L. Steavenson.
C. = Bee Hive. (North of England Institute of Mining and Mechanical Engineers, 1903). M. R. Kirby.
D. = Retort Coke Ovens. (Iron and Steel Institute Journal, 1902). J. Thiry.

11219. I think the members of the Commission have before them copies of this table ; therefore, if you wish to call our attention to any special points, will you do so ?—In the first place, I have taken an ideal evaporative power of the coal—that is 15.

11220. That is in the first line of the table?—Yes, of the first three, A is an ideal Beehive, B and C relate to Mr. Steavenson's paper and Mr. Kirby's paper. The column D refers to a retort coke oven, and I have taken the data for this calculation from the paper by Mr. Thiry, in the "Journal" of the Iron and Steel Institute, 1902.

11221. C is a Beehive also?—Yes.

11222. A, B, and C are all Beehives?—Yes, but B and C are put in because they represent actual data which are given in the columns I refer to.

11223. And column D is one of the modern retort ovens?—Yes.

11224. Of what stamp?—The Otto Hilgenstock.

11225. Does this relate to one particular retort, or is it an average of a number?—This relates to one system, but it is the only one of which I can get the complete data.

11226. Now that we have this before us, will you shortly call attention to the results obtained here?—If you take the evaporative power of the coke, looking at it simply from a thermal point of view, then because the coke is greater in D in the retort oven, and there is a larger yield of coke, the evaporative power of the coke is greater. I may say that in estimating this I have assumed the coke to contain a rather high percentage of ash, namely, 7 per cent.; of course, that is rather a disadvantage. These calculations, I may say, are approximate calculations made simply to form some conception

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of the relative value of the different methods. Then it will be noted that all the evaporative power of the volatile portion of the coal is in the ordinary oven used for coking purposes. In B and C there is a saving, but it is not very large. When you come to the retort oven you will note that there is a very considerable decrease in the amount of heat which is required to coke the coal.

11227. It is one quarter of the first one?—Yes, 1·5 as against 6·5. That, of course, includes the loss in the chimney and the loss by radiation, and I suppose the loss in watering the coke. Then this method also supplies a certain amount of gas which is representative of ·66 tons of water evaporated per ton of coal, and there is tar and ammonia, which are obtained at the expense of heat equivalent to that required for the evaporation of 1·14 tons of water.

11228. Now the second table?—I have taken those results and expressed them in terms of the total heat value of the coal at 100. You will see at once that the heat utilised in coking in the first is 43·4 per cent. Then there is a decrease under B and C, and under the retort oven it is only 10 per cent. That is a calculation, and I might point out at once here that this calculated result under D agrees practically with the result obtained in America in tests, an account of which was given by Dr. Schniewind in Glasgow.

11229. It is practically in the same proportion as your previous calculation, taking the evaporation tables?—Yes, it is only another way of expressing it. Then I have used these data in Table III. to give one an idea of the heat employed to produce one ton of coke, expressing the heat always throughout in amounts equivalent to tons of water evaporated, and in the ordinary oven without any utilisation, the figure would be 10·8 tons; in the Beehive it is 9·4 and 9, whereas in the retort oven it is only 2. These calculations of the heat balance in the case of the retort oven are confirmed by tests made in America described by Dr. Schniewind, of New York, who gives the following statement:—

	Per cent. of Calorific Power of Dry Coal.
Coke	72·2
Tar	4·1
Surplus gas	12·7
Heating gas	10·7
Ammonia liquor, &c.	·2
	100·0

I might draw your attention here to this fact, that the tests indicate that the coke in this case is got at an expense of 10·9 per cent. of the heat value of the coal, whereas in my calculations it comes out at 10 per cent. I have introduced a comparison here between the method of carbonising coal in the retort oven and that adopted where coal is used for the manufacture of gas—in the gas retorts. Taking the data supplied from German experience, it is 24·8 per cent. of the heat value of the coal which is utilised or is needed to carbonise the coal; whereas if you take the returns of the South Metropolitan Gas Company for last year, I estimate that the expenditure of coke there is equivalent to about 15 per cent. of the heat value of the coal.

11230. Then the result of that is that in the retort oven the carbonisation is effected by an expenditure, you say, of 10·9 per cent. of the thermal value of the coal?—Yes.

11231. This is purely your chemical point of view; you have not had any experience practically, I understand, have you?—No.

11232. There is nothing that you wish to say, or can say, beyond this as regards the practical working of these ovens. These data are derived from other people's experience?—Yes, entirely; and from visits paid, and also from the literature on the subject.

11233. (*Sir Lindsay Wood.*) I should like to ask whether these bye-product ovens, as to which you have given us the information here, are a fair sample of those in use now?—They represent, I think, the most recent form of oven; they are in use in the county of Durham, and, I believe, are giving every satisfaction.

11234. Do they differ much from the Simon-Carvès or any other class?—A great many advantages are claimed for them over the Simon-Carvès, and one is that in this form of oven the flues are vertical flues. I believe the oven can be made tighter than in the Simon-Carvès, and they claim, and I believe with justice, that they obtain a good yield of gas—a considerable surplus of gas; in fact, I learnt this morning from a coke manufacturer that he has measured the unused gas obtained from such a batch of ovens, and he finds that that it is about 30 per cent. of the total volume of gas produced.

11235. Then commercially you think they are a success?—Well, it is scarcely for me to give an opinion upon a commercial point. I should judge, from the fact that certain firms have gone very largely into it, that the system must be a success.

11236. (*Sir George Armytage.*) You have no figures to show any comparison between them and the other retort ovens?—No; the data supplied in the literature on the subject are not sufficient to make the comparison.

11237. (*Sir Lindsay Wood.*) There is no doubt that they are a great improvement upon the old Beehive, if nothing else?—Oh, yes, a great improvement, I should point out, thermally; it is the least wasteful method of getting coke, from the thermal point of view.

11238. (*Mr. Teall.*) Can you tell us anything about the coking of peat?—I have no experience of it.

11239. I believe it is done in Sweden?—Yes.

11240. (*Dr. Le Neve Foster.*) Can you tell us anything about the utilisation of these gases by gas engines?—I have no experience of it. One can see from the composition that thermally they should be very valuable in a gas engine *

11241. Then you would be prepared to advise collieries to go in for a plant of this kind, and to use gas engines instead of steam boilers?—Well, not altogether, because there is a certain amount of the gas which is used for coking, and after it has been burnt round the ovens you can utilise the waste heat from the burnt gas for the purpose of steam raising, so that you can get, as a matter of fact, a sufficient amount of steam in that way to work your colliery.

11242. But is it not better to employ the gas in a gas engine than to burn it under a steam boiler?—With this form of oven it would be rather a cumbersome thing, I think, to have to cool the gas down after it has burnt round the oven.

11243. You have taken all the bye-products out of it?—Well, if you follow me, you take the gas from the oven, you pass it through the condensing plant, and then say three-quarters of that you return to the oven after you have passed it through the condensing plant and burn it in the flues outside the oven for coking purposes. Then seeing that the burnt gases must travel a long way before they go to the chimney, you can get a considerable amount of waste heat from them for steam-raising purposes. Then you have still the quarter left of purified gas, which you could use for gas engines.

(*Sir George Armytage.*) But I understood your point to be that a portion could afterwards be used for steam-raising purposes; would it not be better to use that for gas engines instead of for steam-raising purposes?

11244. (*Dr. Le Neve Foster.*) That is my point?—I should not like to express an opinion upon that. I think there would be difficulties in the way of cooling it.

Explanatory Note sent in by Professor BEDSON.

March 14th, 1903.

* In my reply to the question raised by Dr. Le Neve Foster (Questions 11240–11244), I had in mind the fact that in working such a bye-product plant there would always be surplus gas, which could be advantageously used in gas engines. Still there is a considerable volume of burnt gas which leaves the flues of the ovens at such a temperature that it can be employed with advantage under boilers, but is not suited to work gas engines.

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Professor Peter Phillips Bedson, M.A., D.Sc.

25 Feb. 1903.

11245. (*Professor Dixon.*) I should like to ask you one question as to where you get the figure 24·8 per cent. of the heat value of the coal being used in Germany—in making gas, I presume ?—Yes.*

11246. When you speak of distillation in gas retorts, does that refer to coal gas ?—Yes, for lighting purposes.

11247. Is that not rather a high figure? Where do you get that from?—It is quoted by Dr. Schniewind in his paper at the International Congress in Glasgow.

11248. Does it refer to modern gas-making plant?—I should think not.

11249. It is very much above the ordinary figure, is it not?—I should judge so; but I think the South Metropolitan Gas Company work very economically, do they not?

11250. Yes; their figure is 15 per cent., you see?—Yes.

11251. I should have thought the average was about 17 to 18 per cent. What is your own experience?—I have not had any actual experience of that.

11252. Might I put the question in another way. Out of 7 or 8 gas retorts, from how many of those would the coke be taken for selling, and in how many would it be used in the furnace?—I could not say from actual experience.

11253. It is generally about 2, is it not?—Yes, I believe so. But that figure of 24·8 per cent. is an average based upon several quoted by Dr. Schniewind in his paper.

11254. In the gas works that I know it is usual to use about 17·5 per cent. of the total heat value of the coal—on the assumption which you give in your statement of the coke value being about 70 per cent. of the original coal?—Yes; I should be prepared for that, but it is, of course, stated to be much higher; in some cases it is stated to be about 40 per cent., but that is a text-book statement.

11255. As a matter of fact you know it; you are familiar with gas works, Professor Bedson?—Well, some; not very many.

11256. (*Sir George Armytage.*) I dare say you have heard, if you do not know it practically, that the price of the Beehive coke seems to be higher than that of the coke made in these new retorts; it is at a higher price in the market. You have heard that, I dare say?—Yes.

11257. What is your real opinion upon that? Is there any real difference in value, or is it a sentiment?—Of course, there is coke and coke. It is very difficult to get a comparison between the Beehive and the retort oven coke. Of course in making the Beehive coke they use the best coking coal, and the retort oven coke is not made necessarily from the best.

11258. Then you do not know of any case which you can quote where the same coal has been used, and where comparisons have been made afterwards? No, I do not know of any such case. Of course we know that the ironmaster claims that the Beehive coke is much superior to the retort coke.

11259. Some say so?—Yes; and yet you find ironmasters who are using these retort plants.

11260. (*Dr. Le Neve Foster.*) If you were using coking coals of the same quality, and the Beehive gives you 56 per cent. and the retort oven gives you 70 per cent., would not the retort oven coke have a smaller percentage of ash in it?—Certainly.

11261. If the coals are of equal quality, ought not the bye-product coke to have a smaller percentage of ash than the Beehive?—Certainly, but it is the physical structure, I believe, that the ironmasters complain of.

11262. Yes, they do. Retort oven coke is softer.

11263. And it has not got that lustre?—No. That, of course, to a large extent accounts for the preference.

Explanatory Note sent in by Professor BEDSON.
March 14th, 1903.

* In explanation of this figure, 24·8 per cent., to which Professor Dixon drew attention (Question 11245) I should like to add that it represents the heat used and lost in the distillation process. It is based on the average of three sets of data given by three different German authorities and quoted by Dr. Schniewind in his paper read before the International Congress of Engineers at Glasgow in 1901. It does not represent only the heat supplied by the coke burnt under the retorts, which as will be seen from the statement below is equivalent to 19·2 per cent. of the coke made from 100 lbs. of coal, but includes also the heat not recovered in the form of coke, gas or tar. Whereas Dr. Schniewind's tests, to which I refer in my evidence, show that in the bye-product ovens the heat used and lost in the distillation is 10·9 per cent. of the calorific power of the coal. The following table represents the heat distribution in products of distillation in ordinary gas-retorts. The heat in 100 lbs. of dry coal is distributed thus :—

In coke, saleable - - -	47·8 per cent.
In coke, used for heating retorts	11·4 „ „
In tar - - - - - -	6·1 „ „
In gas, saleable - - - -	21·3 „ „
In ammonia liquor, sulphur in purifiers and loss - -	13·4 „
	100·0

Mr. RICHARD PEARSON, called; and Examined.

Mr. Richard Pearson.

25 Feb. 1903.

11264. (*Sir George Armytage.*) You are Managing Director of the Natural Gas-fields of England?—Yes.

11265. (*Mr. Bell.*) Is it a Limited Company?—It is.

11266. Has it a large capital?—No, or rather not large for such undertakings as compared with America.

11267. (*Sir George Armytage.*) Perhaps you will deal with that later on. Will you proceed with your statement?—The discovery of natural gas in Sussex is by no means so recent as many people think. The first find of gas which has come to my knowledge was made in 1836, at a place called Hawkhurst, in West Sussex. Some men engaged in sinking a well, after the first 90ft. of digging, commenced work with an auger-bit, working by the light of ordinary lanterns held at the bottom of the well. When a point about 240ft. below the level at which boring was commenced had been reached, the auger suddenly disappeared into a cavity, there was a rush of gas, and two of the workmen were burned to death. This discovery was never followed up, for reasons I can show. Natural gas next appeared during the famous Sub-Wealden borings of 1873–1875 at a place called Netherfield, west of Robertsbridge, on the South Eastern Railway line to Hastings.

It was reported that frequently during the boring operations there were outbursts and explosions of gas. I have reason to believe that the gas discovered on this occasion was burned for several months. Professor W. Topley, in his "Geology of the Weald" (page 43), records that in the course of the Sub-Wealden boring, at 602ft., a bed of Kimmeridge shale 2ft. thick, very rich in petroleum, was met. This was about 312ft. from the top of the Kimmeridge clay, the Kimmeridge having been encountered at some 290ft. from the surface. This discovery of gas and petroleum, like the first I referred to, was not followed up. But one's surprise at this neglect is lessened on reflection that natural gas was not used to any great extent in America before 1885. It was about that date that Mr. Andrew Carnegie began to use natural gas in his now world-famed steel works. The development of the natural gas industry of America may be said to date from 1885. The growth of the use of this gas in America may be judged from the fact that to-day, in the iron mills, where hundreds of stokers worked in the early eighties, one sees only a few lads turning on gas-cocks. Wherever gas is available, it is *the* fuel for the progressive-minded ironmaster.

11268. Have you seen this yourself?—No, not the mills at Pittsburg. This makes it easy to understand

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how it was that no practical working followed the early discoveries of natural gas in Sussex. The finds were made some years before anything was being done with the gas in America, and nobody cognisant of the possibilities seems to have heard of these important discoveries. To revert for a moment to the Sub-Wealden borings carried on at the public expense to prove what underlay the Wealden area, this undertaking was not a waste of money, as so many people think. Quite close to this borehole, to-day many men are, and have been for years, employed in mining some of the finest gypsum the world produces, and I have seen some of this gypsum so impregnated with petroleum that it might be worked to produce that well-known illuminant.

Turning our attention to Heathfield, as the discoveries at Heathfield are the reason for my presence here to-day, some time ago a well-known firm of well-workers were sinking a well for water on the site of the Heathfield Hotel. This hotel is situate some 50yds. from Heathfield Station (on the London, Brighton, and South Coast Railway), and stands about 20ft. above the level of the railway station. At a depth of about 300ft. the borers met with inflammable gas. But they were seeking water, and none being reached, the borehole was cemented up and abandoned. A short time afterwards men employed by the same firm were at work sinking a well for the London, Brighton, and South Coast Railway Company for water to supply the locomotives at Heathfield Station. The shaft was sunk in the cutting at the station end of the tunnel. In August, 1896, while working at a depth of 300ft., they also found an inflammable gas. But no water was reached even when another 100ft. had been sunk. The casing tubes were accordingly withdrawn, except a few at the top, and once more work was discontinued. The discharge of gas, however, continued steadily—that was for one or two years—the gas being lit from time to time to gratify the curiosity of visitors. About this date (1898–9), two or three years after the discovery, the railway company decided, as the supply was not diminishing—for one or two years it continuously kept coming up—to put the gas to some useful purpose. Consequently they tapped the bore-hole, and from that day until now the railway station has been lit with natural gas, the consumption averaging about 1,000 cubic feet per day. Hearing of this very practical outcome of the second find of gas, I expected to hear later that extensive explorations would be made to determine the extent of the gas-bearing area in the neighbourhood. But finding that no further steps had been taken, I communicated with some American friends who were thoroughly conversant with the natural gas industry of the United States of America. These men asked me to take steps in the matter at once. I located positions for six experimental bore-holes to be made, and we commenced boring.

11269. Then these gentlemen who started this were Americans, were they?—Yes.

11270. (*Mr. Bell.*) When was that?—A year ago.

11271. (*Sir George Armytage.*) Since 1898, I understood you to say?—No, it was in 1896 that the Brighton Company put the bore-hole down, and in 1898 the Brighton Company began to use the gas for their station. What I am now describing was only just over a year ago. I located positions for six experimental bore-holes to be made, and we commenced boring. In each and all of the bore-holes we have struck gas, at levels varying from 300 to 400ft. from the surface, the farthest (from the company's borings) of the six being distant some three-quarters of a mile from the railway station. These six bore-holes are started in the geological formation known as the Hastings bed, which in the Heathfield district lies some 400ft. geologically above the Sub-Wealden boring at Netherfield, which was started in the Purbeck bed.

11272. You speak of the Hastings bed?—Yes.

11273. Is it a bed of clay, or what?—It is the lowest part of what is known as the Weald clay—the Hastings sandstone.

11274. Then these bore-holes are all within a radius of three-quarters of a mile?—Yes. This Hastings bed is composed principally of sandstones, iron bands, marl, &c., which constitute it a "cap," admirably adapted to act as a natural lid to a natural holder for enormous volumes of gas.

Mr. Richard Pearson.

25 Feb. 1903.

(*Mr. Bell.*) I do not quite understand that; you say "This Hastings bed is composed principally of sandstones, iron bands, marl, &c., which constitute it a 'cap.'"

11275. (*Sir George Armytage.*) Do you mean it is a sort of concrete?—The iron especially.

11276. (*Mr. Bell.*) It covers the marl—the Weald clay?—No, it covers the Kimmeridge clay; it covers the gas area.

11277. (*Mr. Brace.*) And that bed must be broken through before the gas can come out?—Yes.

11278. (*Sir George Armytage.*) Have you any idea from your boring what is the depth of the gas-bearing portion?—We have proved that there is a gas-bearing belt area of a thickness of 100ft., but we have only proved the top gas horizon.

11279. Do I understand you to say that when you have got through this cap, as you call it, of sandstones, iron bands, marl, and so forth, you then come upon the gas?—Yes.

11280. That is the next mineral, as it were—the next element you have all through?—We then come to the Purbeck. The gas is just above the Purbeck where we have struck it. Then we come on to the gypsum formation of the Purbeck—the limestone formation—and then through that we get on to the sand and the Portland stone, and then to the Kimmeridge.

11281. Is the gas lying in all those strata?—We hope to prove it very shortly.

11282. It is all spread about those strata?—Yes, I think so. Heathfield is built on the famous Mid-Sussex anti-clinal. The Sub-Wealden boring, started in the Purbeck bed situated some 9 miles east, is on the same anti-clinal. This fact conclusively proves the relative identity of the two discoveries. Many people say that it is impossible for gas to exist in Sussex, but they must talk without the slightest knowledge of the geological nature of the county.

The Purbeck formation is well known to have bituminous beds throughout its whole course. For example, at Swife's farm, Pounceford, where the Purbeck is exposed, between Heathfield and Netherfield, several tons of bituminous shales have been distilled, giving off paraffins, &c. The Kimmeridge clay which lies some 200ft. below the Purbeck, has been proved to be the thickest Kimmeridge bed in England, and 250ft. of this bed is known to be of a very bituminous nature. Again, the Oxford lying below the Kimmeridge, is also known to be very bituminous.

In searching for natural gas in the United States, three points are mostly held in view: Firstly, have the rocks been disturbed? (If so, no further time need be spent looking for gas.) Secondly, is it an anticlinal formation? Thirdly, are any bituminous beds known to be below? Holding these points in view, I may say: (*a*) in this part of Sussex we have got the iron formation of the Hastings sands, practically not disturbed at all: (*b*) it is well-known to geologists that the North and South Downs are simply the outlayers of an enormous anti-clinal: (*c*) there are three successive bituminous beds known to lie immediately under the sandstones.

Therefore, there is every probability of the existence of a rich, extensive, and lasting gas-field. It is well known that certain beds of the Kimmeridge clay have been burnt as fuel at Kimmeridge, in Dorsetshire.

11283. That is why it is so called I understand?—Yes, so far as the English name is concerned, but it goes by different names. I am sure that most of the gas in that county must have been allowed to escape, owing to the absence of the overlying beds of sandstone, but nevertheless, within the last few days I have heard of gas being found at Bassingbourne in Cambridgeshire, where also it is known that the Kimmeridge comes to the surface. There is a well there giving a fair supply of natural gas. Again at King's Lynn, I understand there has been talk recently of starting a distillery for the distillation of paraffin from the Kimmeridge shales. This, I think, is sufficient proof of the exceedingly bituminous nature of the Kimmeridge bed.

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Mr. Richard Pearson.

25 Feb. 1903.

At Mayfield, about five miles from Heathfield, we have commenced boring in two positions on the Hastings sand, and in one we have already struck gas, while the other—at a depth of 300ft.—strikes a stratum of 20ft. giving a splendid yield of petroleum.

11284. Does that mean that the petroleum comes up to the top?—No, instead of getting up water, we are getting up sluice buckets with nothing but petroleum in them now.

11285. That is to say, from your boring?—Yes. I take it that there we are really at the top of the Purbeck or the gypsum formation, and whenever there is a fault in the gypsum formation at Netherfield, that is where you find the petroleum that I speak of.

11286. What is the diameter of your bore-hole?—Some of our largest are 10in. and they range down to 5½in.

11287. You put down a bucket?—Yes, what I call sluice buckets.

11288. Does this petroleum rise at all in the hole, or does it remain at the level at which you take it out?—It does.

11289. (*Professor Lapworth.*) What do you mean by a splendid yield—how much?—Well, our bucket holds some 4 or 5 gallons, and we could get easily a barrel or two per day out of that present hole.

11290. With a 10in. bore-hole?—No, that is 5½in.

11291. (*Mr. Teall.*) Where does Mayfield lie with regard to Heathfield?—Five miles north towards London—it is towards Tunbridge Wells. We are now boring over some 200 square miles in the county of Sussex, and hope soon to prove large supplies of gas throughout this territory. At Heathfield, we are already supplying from 70 to 80 houses with natural gas for lighting (used with incandescent mantles), heating, and cooking. We are lighting the street lamps in the town, and using the gas for the gas engines employed in our own work. We have got facilities from the London Brighton and South Coast Railway Company, to lay our conduit pipes along their lines to supply the gasworks of the large towns in the vicinity.

11292. (*Sir George Armytage.*) That means, I suppose, that you are paying them a wayleave?—Yes.

11293. Has this gas which you are using for lighting got about the same candle-power as ordinary lighting gas?—No; I will mention that point a little later. Eastbourne lies some 16 miles to the southward of Heathfield. The Eastbourne gasworks supply about 1,000,000 cubic feet of gas per day, using a fairly good gas coal, which yields about 10,000 cubic feet to the ton. This means, that over 100 tons of coal must be carbonised daily to supply Eastbourne with coal gas. Nearly 40,000 tons of coal must therefore be carried to Eastbourne yearly to supply the inhabitants with gas for lighting.

11294. Now with regard to the composition of this gas?—As most of you gentlemen know, the gas in its native state gives—in an ordinary "Bats-wing" burner—a light of about 12 candle-power. Some people have gone so far as to say that the gas must be enriched on coming from the earth. This lighting power is not a unique feature of Heathfield gas, as some of the American gas gives equal candle power. The majority of the natural gas-fields of America, however, yield a gas which gives but a poor light in ordinary burners. Professor Dixon who (I believe), analysed Heathfield gas for the Coal Commission, has put on record figures which account for the high illuminant value it has been proved to possess. He gives as its constituent parts:

See Appendix IV.

Methane	93·4 per cent.
Ethane	3·0 per cent.
Nitrogen	2·7 per cent.
Carbonic oxide	0·9 per cent.

It is the 3 per cent. of ethane which gives Heathfield gas its conspicuous superiority to the American natural gas as an illuminant.

11295. You say it is the 3 per cent. of ethane which gives Heathfield gas its superiority as an illuminant. What is the candle power?—12. Boghead coal gas, which (I believe) is the highest candle power gas ever produced from coal, has only about 4.7 per. cent. of ethane in its composition. But the great point in the future of Heathfield gas will be its value as used to provide machine power. Our engines in use at Heathfield consume from about 13 to 15 cubic feet indicated horse-power to one brake horse-power, as against 20 to 25 in the case of coal gas. These figures are in themselves sufficient indication of the enormous saving that the general use of Heathfield gas will effect.

11296. About 13 cubic feet in what period?—Per hour, per one horse-power—13 cubic feet to the brake horse.

11297. You want 13 cubic feet to produce one horse-power, do you not?—Yes. The heating power that is to be obtained from a gas containing 93·4 per cent. of methane need not be enlarged on to anybody in the slightest degree conversant with gas figures.

Natural gas of the Heathfield quality, easily stands in front of all other fuels. In an estimate made last year, it transpired that in America 1,000,000 households, and 4,000,000 people were furnished with this ideal fuel and lighting gas. There were over a 100 iron and steel works using natural gas exclusively as a fuel. The fuel charges amounted to less than three dollars per ton of sheet steel. In Pittsburg, the proprietors of a flint glassworks were saving 49 per cent. of their fuel bill by using natural gas in place of coal.

11298. What was their fuel previously; was it coal?—Yes. The glassworks of America last year were to the number of 219 using natural gas.

The comparison of gaseous fuels is approximately as follows:—

Per 1,000 *cubic feet at* 40*F., at atmospheric pressure.*

	Units of Heat.
Natural gas (from American statistics)	1,100,000
Coal gas	735,000
Water gas	322,000
Producer (gas heated)	156,000

1,000 *cubic feet of natural Gas evaporates from* 60 *F.*

(1.)	Lbs. of Water.
To steam, say 212F.	900
1,000 cubic feet coal gas, say 212F.	600
1,000 cubic feet water gas, say 212F.	250
1,000 cubic feet producer gas, say 212F.	115

(2.) The following table will give a fair example of the volumes of gas needed to produce 1 b.h.p. in any well-known make of gas engine:—

	Feet per b.h.p.
Heathfield natural gas	12 to 15
Coal, or town's gas	20 to 25
Water gas	60 to 80
Producer gas	100 to 120

(3.) Taking London and the South of England as a whole, every pound of coal burnt in gas production has to be carried by rail or water from a great distance. I might say that for any heating whatever that it is used for—any industry—it has to be carried; but I am simply speaking with regard to gas production. The iron works of the Wealden area employed some 50,000 men in 1760, when the discovery of coal in the North took the iron-working away from the South of England. To-day not an ounce of iron is smelted in all the Wealden territory; no glass is made although I believe the sand so plentiful at Mayfield is sent in large quantities to the North, for glass making.

Now if we can prove incontestably that we have one immense gas-field lying under the whole of the Weald, then we can revolutionise the industrial life of the South of England. The iron is there, the sand is there. Both can be worked with fuel on the spot, that fuel issuing from the earth in huge quantities and being the cheapest in the world.

The cost of carriage obviated, in addition to seeing the old industries revived, I look confidently to new work being opened up, and new industries going on in an enormous tract of land at present devoted solely to agriculture.

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(4.) I have heard recently that the L.B. & S.C. Ry. Company purpose adopting electric traction on a large section of their line. As this Company's metals pass over about 40 miles of what I am confident is gas-bearing and, there should be no difficulty in obtaining power for the production of their electrical energy. Messrs. Westinghouse have built in America gas engines of 1,500 b.h.p., to work with natural gas.

(5.) The pressure at Heathfield generally varies from 134 to 200 lbs. to the square inch. As to the permanency of the supply, I may state that in China natural gas from identically similar geological formations has been used to evaporate salt for over 1,000 years. The Chinese gas fields lie on the frontier of Tsetchuan. The gas is used with great economic advantage at Medjansk, in Russia, and is employed for municipal lighting at two small towns on the Zuyder Zee in Holland. In all these cases the gas issues from identically similar strata.

(6.) I feel certain that a good supply of gas will be found, a supply with great pressure, of undoubted permanency. In the United States of America there are some 11,000 wells bored. At Heathfield at present we have nine, and are sinking 10 others. There is indubitably sufficient gas bearing land to warrant the boring of many thousand, and I can only say that thousands of wells will be bored. We are now being asked, "Can I have land with gas on it?" for this or that industrial purpose.

11299. You say "We are now being asked," who do you mean is now being asked?—I am referring to the Company.

11,300. Then what has your Company done; has it acquired freehold land for putting down boreholes or what?—We have acquired freeholds, not to a very great extent, but we have mineral rights over some of the largest estates in Sussex, paying the landowners a royalty.

11301. For their gas rights?—Yes.

11302. That means to say that they will not allow anybody but you, so far as they know, to extract the gas from their land. Is that so?—That is so.

11303. You have been taking those in a similar sort of way to coaling leases, have you; or have you taken options for limited periods?—Fifty years. We have an option for one year, and we spend so much money in putting down bores to see whether we think it is worth while going on, and then we have the right to leases running 25 and 15 years.

11304. Which you have agreed beforehand?—Yes.

11305. Or you can give it up in a year?—Yes.

11306. Up to the present you have not gone more than ¾ of a mile from the station?—That is as far as Heathfield is concerned.

11307. How far from that are you now putting down boreholes?—We are putting down boreholes nine miles off at Netherfield, and 15 miles off at Ticehurst. We are five miles away at Mayfield, and we are starting at Crowborough and also at Wadhurst.

11308. Has the Company a large capital?—No. When I say no, it is large, but not as large as the capital of companies in America. The Steel Trust, in taking over Mr. Carnegie's works, valued that gas-field of his at £5,000,000. Our capital is £100,000.

11309. Are the gentlemen who were associated with you in this concern experts in America in this matter? I mean have they been connected with the same business?—Only financially; that is all. One of them has the largest brass business in the States, and he uses a lot of natural gas.

11310. Do you know with regard to these wells of America, whether after long periods of time the pressure goes down or the gas exhausts?—Yes, it does, but the initial pressure in America is very much greater than ours. I firmly believe that as we get down lower into the Portlands we will get a higher pressure on what I call our second horizon of gas.

11311. Have you any estimate of how the pressure goes down; have you any period of years or anything of that sort showing how it suffers?—Yes, in a place called Stuartsville in 1888, the pressure was 450lbs., and in 1890 it had dropped to 275lbs.

Mr. Richar Pearson.

25 Feb. 1903.

11312. More than half?—Yes, but even that 275lbs. is a higher pressure than we start at.

11313. Does that arise from the great number of boreholes; from the supply being exhausted by other boreholes?—They put the bores very close together from what I understand, and from what I have seen in America, but of course if it is a dome and the gas is at anything like equal pressure, and they get down many together they will use up the total supply quicker.

11314. What is the largest borehole they put down?—Do you mean in America?

11315. Yes?—Their largest borehole is about 8½in. Ours is larger than the American borehole; it is 10in.

11316. That is all?—Yes.

11317. Do they line that?—Yes, it is steel lined. All our wells are steel lined bores.

11318. That is to prevent any escape into the other strata on the way up, I suppose?—And also to keep the surface water out. They have found, especially in the deep wells in America, that they have to guard against that; they have to go 2,000ft. in America, but we are only going down 300 ft. in England at present.

11319. What have you at the bottom of your tube; a sort of rose?—No, we put down perforated pipes into our gas belt. The station well, the first well that was put there, fell in over 200 feet, and the gas still came through at as nearly a good pressure.

11320. What size are those perforations?—About an inch.

11321. On the vertical side of the pipe or of the tube?—Yes.

11322. Then the tube is not sealed at the bottom, I suppose?—No.

11323. Have you experienced any difference since sinking the boreholes?—Not the slightest yet.

11324. None whatever?—No, but we have got down, of course, a very few as compared with what there would be.

11325. Then so far as you are concerned as a Company, you would only control the land which you have bought, and the rights of the persons from whom you have got it?—That is so.

11326. So far as you know, in boring for natural gas you would be in exactly the same position as a man who is sinking a well on his own property?—Yes.

11327. And running the risk of another man doing better and tapping it. Is that so?—Well, if both wells were put down close to the boundaries they would do so, but I do not think gas wells at 50ft. apart would draw very much from one another.

11328. What are you liable to suffer from, breaks, or throws, or what? What is likely to smash you up at any moment that you know of?—I do not quite follow.

11329. What I mean is, I gather from part of your evidence that there were shakes or breaks in some of these wells in America, which caused them to cease?—We would not think of starting a surface well on what we knew for certain to be a geological fault.

11330. That is what I mean, on faults?—No, we would not think of starting there. We would want an absolutely undisturbed surface. With regard to the whole of the Weald I do not think it is very much disturbed, although there are parts that are disturbed; and the Weald is certainly a very large area.

11331. (*Sir Lindsay Wood.*) What is the extent of the area, many miles?—Oh yes; the Wealden area runs straight into France, the geological line is known.

11332. (*Sir George Armytage.*) Yes, but you cannot control that?—No, I was talking of the area of the Weald itself.

11333. (*Sir Lindsay Wood.*) I want to know the extent of the area under which you think it is practicable to get gas?—I think gas lies under most

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Mr. Richard Pearson.

25 Feb. 1903.

of the Weald, and the Weald in England I should say is over 30 miles wide by 40 miles or more.

11334. It is a very large area ?—Yes.

11335. (*Sir George Armytage.*) What is the total horse power you are now working from this gas ?—In one engine ?

11336. No, the total ?—Not more than 20 horse-power. We are only doing it for our own purposes, and we are pumping for the Railway Company. We displaced a 6½ h.p. steam engine by 1½ h.p. gas engine ; we are pumping their water at Heathfield. We are now starting on mills, and in a few days we shall have one or two of 10 h.p., but we are only doing that to-day for ourselves.

11337. What is the pressure per square inch ?—200 lbs.

11338. (*Mr. Brace.*) Have you come across coal in your boring operations at all ?—No, but at 35ft. down on the sandstone we do come across what is a very fair cannel ; it is very narrow, and it is what most people would call lignite, but it certainly is of a cannel formation. Further down, of course, the Kimmeridge shale is well known to be about as valuable for gas enriching purposes, as the paraffin shales of New South Wales, it is more sulphury.

11339. I do not suppose that this will be information to you, but it might be interesting to state that within a few miles of my home at Pontypool, in Monmouthshire, there is a pipe with a hole as wide as those electric lamps, which has been burning there to my knowledge with a great flame as big as that for many years ?—I have seen it two or three times. We own that property to-day. Some people imagine that gas comes from the old coal workings, but directly below it is the carbonaceous limestone, and that is where the great gas finds are made in America.

11340. I should not imagine myself that it came from the coal, because we are on the borders of a great fault there ?—True ; and the carbonaceous limestone is most certainly below it, and that is the formation in the States, from which they get their large bodies of natural gas.

11341. (*Mr. Bell.*) You say, " In an estimate made last year it transpired that in America 1,000,000 households and 4,000,000 people were furnished with this ideal fuel." Over what area was that ?—I could not tell you that. It is from the records they have in the " Electrical World " of New York.

11342. In mentioning figures of that kind do you wish to convey to the Commission that you have a field of natural gas at all in comparison with those figures ?—We have a field to-day as large as the Pittsburg field ; we know that.

11343. An area ?—Yes, an area ; if the gas is under that area we have an area that ought to contain gas equal to the Pittsburg. What I meant to convey was that in England up to the present no natural gas has been used for any purpose, to my knowledge, or very little ; I believe I am right in saying that. But in America at the present day there are 1,000,000 households using this gas won from the earth instead of gas won from coal.

11344. I suppose the success of the development of this industry will depend entirely upon the quantity of gas that you may have within the area of your leases ?—Quite so.

11345. (*Sir George Armytage.*) That you can only tell by experiment, I suppose ?—True.

11346. (*Mr. Bell.*) Are you laying out your plans for any definite anticipation of a quantity ?—Yes ; we hope to start at once laying down a very large gas main to both Brighton and Eastbourne. That is for domestic use simply : not for industrial use.

11347. For lighting ?—For lighting ; for selling in bulk to the gas companies. All those gas companies in the south must certainly import all their coal, if I may use the word " import," from the north.

11348. Eastbourne, you say, consumes 40,000 tons of coal a year ?—Yes, 100 tons per day ; 36,500 tons would be 100 tons per day. But the gas manager there told me that he is now making 1,300,000ft. per day. In the " Gas World " I notice they do not put that figure down, therefore I have reduced it.

11349. Can you give us any idea as to the quantity of gas that you may be able to raise out of this area if your operations are carried out on the lines that you contemplate ?—I think it would be absolutely impossible to say ; it would be simply guesswork.

11350. As much as would supply those two towns ?—I think as much as would supply London as well, which uses £6,000,000 worth per annum ; but it is simply guess work. What I mean is this, that if we have in this district 100ft. of a gas horizon at a pressure of 200 lbs. the volume of gas is something tremendous.

11351. One hundred feet deep ?—We have proved 100ft. deep of gas.

11352. That is of gaseous material ?—No, of gas in a pressure belt. The gas may come from 100ft. or 200ft. below that again—that is to say, the formation or generation of that gas. I notice that the Geological Society in issuing their latest book on water supplies in Sussex speak very dismally of water in that county, saying that if you get down to the belts of the Purbeck or Kimmeridge, instead of water you may find both natural gas and petroleum.

11353. I do not understand how you arrive at any principle leading you to suppose that a pressure of 200 lbs. to the square inch gives you a certain depth, or from what area that pressure comes. Is that over a certain area as well as the depth of it ? You have taken an area of 300 square miles, have you not ?—Yes.

11354. And you say there is a possibility of obtaining a gaseous material 100ft. thick ?—A gas-holder, if I may use that word ; it is not a gaseous material, because that gas may be formed at much greater depths. It is held there because of the sandstone capping it above.

11355. So that it may go down to any depth ?—Yes.

11356. You cannot form any conclusion as to the millions or billions of cubic feet of gas that it might contain ?—No.

11357. And you cannot tell from the pressure how long this particular well might continue ?—No.

11358. It does look rather ominous that the pressure in Pennsylvania should have dropped from 450ft. in 1888 down to 275 in 1890. Do you know how far the next bore-hole is from that particular one ?—I do not know in regard to Pennsylvania, but I do know that in Pennsylvania many of the derricks for boring are absolutely touching one another : I have seen wells in one part that are put down at less than 20ft. apart—a good bit less.

11359. Your borings are almost on an anticlinal formation ?—Yes.

11360. What is the inclination of this anticlinal ? Does it go down pretty quickly ?—I take it that these anticlinals in that part of Sussex are simply waves in a great anticlinal. The anticlinal proper most certainly stretches from somewhere near Croydon to near Eastbourne. It has been proved beyond a doubt that that it is simply a washout of the chalk—that the anticlinal is an enormous belt there, and that these are waves of that greater anticlinal.

11361. According to your present plans of operations, do you consider you have a reasonable prospect of securing a successful commercial venture by supplying the towns of Eastbourne and Brighton to begin with ?—Yes.

11362. (*Professor Lapworth.*) How much gas have you got already from your well ? How much can you depend upon at the present moment ? Putting speculation entirely aside, what quantity of gas can you take out of the wells that you have already bored ? I quite understand that if you multiplied them in sufficient quantity and obtained the same quantity of gas from each, you may imagine that you may be able to light Eastbourne, and so on, but how much have you actually got from your experiments to found your opinion upon at the present date ?—We have most certainly blown off over 1,000,000ft. per day.

11363. Per day ?—Yes, we have blown it off, we have not used it, it is simply waste.

11364. You have proved it up to that point, 1,000,000ft. per day ?—Yes.

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11365. (*Mr. Bell.*) How long has that continued ?—That was only for our own tests. I do not say that we could continue that for a week, or anything of the sort; but with regard to every one of those wells they never seem to diminish in any way. Of course they are always gaining power by our closing them down. We have no use for our works at present.

11366. (*Professor Lapworth.*) How many wells do you require to supply Heathfield ?—Five wells. They more than supply that.

11367. And on an average you suppose there would be 200,000ft. per day from each of the wells ?—Yes. I cannot say by any means that it would continue at that.

11368. Have you tested the pressure in each well, or the quantity ?—Yes.

11369. And it is upon the experience of those wells that you have entered into these speculations with reference to Brighton and Eastbourne ?—It is quite a speculation in that sense. We have our rights from the railway company, and we are boring all the way down the Brighton line. Our idea is to feed it from different parts down nearly to Hailsham.

11370. Then you imagine you will get this gas over the whole great Wealden anticlinal, say from Winchester on one side, to Brighton on the other side ?—Yes.

11371. Do you suppose this gas comes entirely from the Kimmeridge, the Purbeck, and the beds of coal ?—No, I think we are getting gas also from the Oxford. They have proved gas in the Oxford, and I believe are burning it at Kimmeridge itself—at Weymouth Harbour. I have here "Damon on Weymouth," and he gives a note of it burning in Weymouth Harbour from the Oxford. and I believe one man in Weymouth has lit his offices with gas from the shales of the Oxford clay. That, I think, proves that the Oxford contains a gas-giving substance.

11372. And you suppose this gas comes entirely from the distillation of the carbonaceous matter ?—Yes.

11373. Comparing that with the American fields, you know that in America most of these gas-producing fields are in connection with the great carboniferous system ?—True.

11374. With their mighty coal measures ?—True.

11375. That the areas from which the gas comes are very much greater than the Weald ?—Yes.

11376. There you have an enormous total area compared with this area. But you imagine that there is sufficient bituminous matter in the Kimmeridge clay, and the Oxford to keep up this gas at that pressure ?—I do.

11377. Has the petroleum you have mentioned come up in fairly large quantities ?—Only in the sluice buckets, as I have said. The gypsum we ought to have struck there has disappeared completely, and in place of it we have a mixture of petroleum and limestone shale. I take it, although I may be wrong, that that is the formation of gypsum from carbonates—that is how it was formed, according to my theory.

11378. Then we gather from you that there are two sections, so to speak: there is a vertical section, and, given that the conditions are similar to America, you will have the great quantities of gas they obtain ?—Yes.

11379. But you cannot expect as much, because you have not as much carbonaceous matter. Still, you expect a large quantity ?—Yes.

11380. But the bed rock of all is the existence of these wells which you have ?—Yes.

11381. And you get from five of them 1,000,000ft. per day ?—Yes.

11382. And you calculate from your experience that there will be 200,000ft. to be obtained from every well you sink ?—I would not like to say it will keep up at that pressure; I hope it will; and I quite believe we may hit in some parts very big wells. At the Mayfield Station we are now going down to prove the Kimmeridge and the Oxford.

11383. But all that is in the air ?—Yes.

11384. The essential fact is that you have these wells producing 200,000ft. each per day ?—Yes. We cannot better it to-day at our very best; we are not working quite as scientifically, perhaps, as some of the Americans, who have been at it since 1885.

Mr. Richard Pearson.

25 Feb. 1903.

11385. (*Mr. J. S. Dixon.*) Of what thickness is the strata in which the gas is found, 100ft. ?—Yes, 100ft. That I take as our first gas horizon. Below the Portland bed, or in the Portland bed, I reckon we will find our second gas horizon.

11386. Have these Portland beds been tested for gas ?—No, only in Dorset and on the Portland coast. Damon, in his "Geology of Dorsetshire," speaks of the gas having been found in Weymouth Harbour, and of its burning there and coming very close to the cap of what would be the Portland bed.

11387. The Portland bed must come very near the surface ?—It does in Dorset.

11388. Has it been tested where it crops out ?—Only that there has been spontaneous ignition two or three times in Dorset; and the Kimmeridge, I believe, itself burnt for over seven or eight years there—spontaneous ignition from iron pyrites.

11389. With regard to this 100 ft. of strata in which the gas is got, the whole of the capacity would depend upon the number of fissures that there are in that ?—Well, that is a soft strata of sand and shaly matter, and I take it that it is more or less fissured from end to end.

11390. Impregnated with gas ?—Yes, impregnated—I think so.

11391. But if it is impregnated will not the same state of matters exist as exists in the coal seams ? I do not know whether you are aware that in a seam there is probably a pressure of sometimes 300 or 400 lbs. per square inch, of gas, but there it comes off in such small quantities that it is not available for use. Might not that be the case in this strata; I mean to say you would require to have bores down every few yards to get the gas off ?—That is what they do in America.

11392. In that case, would you not exhaust the gas in the area around each bore in a very short time ?—Well, the life of the American wells, I believe, is from seven to 21 years, and the life of the Chinese, that I have mentioned, which are historically known to be on the Kimmeridge strata, is 1,000 years; but, of course, they are using it in a very small quantity. I have not any personal knowledge of it except from reading.

11393. What I mean is this: in coal seams we know there is a very large quantity of gas ?—Yes, true.

11394. But it cannot be tapped except in exceptional cases so as to flow out in a way that it may be used—it is gradually evaporating as the coal is being worked ?—From the face of the seam as it is working ?

11395. Yes.—But I think that would surely be because even the absolute geological formation of coal itself is compression

11396. The coal is too solid ?—That is so; we would have no coal without it had great compression.

11397. I want to know whether this 100ft is full of fissures so as to form a gasometer, so to speak ?—Yes, we have struck two or three which are only small cavities. I have mentioned that we have dropped an auger, and we have had a drop of 2ft. lately.

11398. In your evidence you mention that as a probable source of power in the sense of gas ?—Yes, that is so.

11399. So as to be a resource as against coal ?—Yes.

11400. I wanted to know whether it is likely to be available in such a state that it can be drawn off in large quantities ?—With regard to that 100ft. which I speak of, which we have proved, of course we are too young to say whether it is full of fissures, but most certainly in what we have done there seemed to be fissures throughout it, and the belt above it is very hard.

11401. Of course that is an absolute necessity, or the gas would not be there ?—Yes, absolute.

11402. Do you suppose that this distillation is going on still ?—According to the Geological paper on Sussex Well Borings, issued lately within the last few months by——

11403. (*Professor Hull.*) Whittaker ?—I think it is Whittaker; it is on Well-Borings—he says there that the water found in the Kimmeridge and the Oxford would be so hot as to be absolutely unpalatable. Well, if that is so, most certainly the distillation is going on to-day.

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Mr. Richard Pearson.

25 Feb. 1903.

11404. (*Mr. J. S. Dixon.*) Of course, that would add to the quantity of gas?—That is stated in that publication. If that is so, most certainly the distillation is going on to-day.

11405. Supposing your most sanguine expectations are fulfilled, could that gas be utilised in two ways, first as a source of pressure, say as steam is used in an engine, and then by combustion?—Yes, certainly.

11406. Has that been done in America?—Yes, many times.

11407. (*Dr. Le Neve Foster.*) In your proof you state that the Sub-Wealden borings were carried on at the public expense. Is that strictly accurate? Were there not private subscriptions?—There were many private subscriptions, but when I say public expense, I believe it was not a company in any sense.

11408. No, it was not.—The Geological Society, I think, took part in it and the Government also subscribed, if I remember rightly, some hundreds of pounds. It was not private individuals who subscribed, but I think from what I have read, of course it is a good bit before my time, two or three public bodies subscribed largely, especially the Geological Society.

(*Mr. Teall.*) No, that is not so, I think.

11409. (*Mr. J. S. Dixon.*) I fancy it was mainly public subscriptions?—I am certain I have seen Mr. Henry Willett, the honorary treasurer, quote subscriptions two or three times from some public bodies.

11410. (*Professor Hull.*) This was the boring at Battle?—Yes.

11411. It went down about 1,800ft., or so?—1,850 ft. or 1,900ft.

11412. That was done by private subscription?—Yes, simply.

(*Professor Hull.*) I do not think the Government took any part in that.

11413. (*Sir George Armytage.*) When was this?—1873 or 1875.

11414. (*Dr. Le Neve Foster.*) Can you tell us how far apart your most distant boreholes are at the present time? How far would it be for instance, from Wadhurst to Heathfield?—17 miles are our most distant ones.

11415. How far is it from Heathfield to Netherfield?—Nine miles.

11416. (*Sir George Armytage.*) Are you down to the gas strata?—No, we are not down to the gas strata at all, but gas has been proved there in the Sub-Wealden boring.

11417. (*Dr. Le Neve Foster.*) If I understood you rightly, you said gas had been tapped at Mayfield?—Yes.

11418. How far is Mayfield from Heathfield?—Five miles.

11419. Have any borings that you have put down been unsuccessful?—No, not yet, none at all.

11420. Does the petroleum which you are finding occur with gas?—In the petroleum at Mayfield we have not discovered gas at present, but I attribute that to this—it is not that we have not passed through gas; I think we have—there is what is known as a water sill; if you get a water column above a gas strata, and if that water column is over-balancing it, the borer, unless he is very expert at it, will certainly miss it. I had a case in point at what I call my No. 3 Well in the valley; they struck a well of gas which was a very wet well, down against a spring, and the engineer came to me and told me there was no more gas there. We were at a depth of 400ft. He said, "We have lost our gas." I said at once, "Draw your water," That is now our best well; it would have been, in the ordinary course, abandoned as a well that had not struck gas, but that is our best well to-day.

11421. That is, for gas?—Yes.

11422. (*Sir George Armytage.*) What do you mean by drawing the water; pumping it out?—Yes.

11423. You take away the water which is in the gas bearing strata?—In the steel lined tube. We have a solid column of water 400ft.

11424. Then did you lift your tube? No, not at all. We simply withdrew our water.

11425. (*Dr. Le Neve Foster.*) What is the cost of the bore-holes?—We reckon we are boring there at 5s. per foot, but that is not including the lining; our lining costs us another 7s. or 8s. per foot.

11426. How much altogether?—That is 12s., 13s., 14s., or even perhaps 15s.

11427. How long does it take to put down a bore-hole of about 300 or 400ft.?—Well, we are gaining, of course, great experience now; we reckon we shall put down a bore-hole and finish it easily in a month.

11428. Are any works being started for the utilisation of the gas?—We have been approached by cement people and others lately from different parts of the country.

11429. Then I understand that your first utilisation will be to supply Eastbourne?—Yes, or else there is an idea of starting plate glass works.

11430. Do you mean plate glass works at Heathfield?—Yes.

11431. Then with reference to the gas bearing stratum where the gas is held, is there not as a matter of fact plenty of room in an ordinary sandstone in the interstitial spaces, the spaces between the grains, to hold a lot of gas?—Yes, the Americans talk always of their gas sands and their oil sands, which are a sandstone.

11432. It is a sandstone with gas or oil lying in the spaces between the grains of sand?—Yes.

11433. (*Professor Dixon.*) Has the composition of the gas, so far as you know, varied since you have begun to tap it?—Not at all. If you speak of analysis we have not always paid the attention that we should to that, but from the light and the naked flame, no.

11434. When I went to Heathfield last October I was shown an analysis that you had made there?—That analysis was not made by us, you see; it was made, I believe, by the railway company when the gas was first struck, and in that analysis they spoke of 18 per cent. of oxygen, I think, if I remember rightly.

11435. They did—I queried that from the very start, and Mr. Dawson, the geologist of Uckfield, has argued against my query since you were there, saying that perhaps oxygen had got in by water, by the pressure of the atmosphere in the water column of that well. Of course it is well known that you can get it in; if you can compress air in water from time to time you get a larger volume of oxygen than you do of nitrogen, after each compression. I think that is so, and that was his argument.

11436. Yes, but your analysis, or the analysis I was shown, showed practically no nitrogen in the gas?—Yes, quite so.

11437. So that there was the difficulty of accounting for 18 per cent. of oxygen, and no nitrogen?—Yes. I think those analyses were absolutely wrong.

11438. You do not think that was correct?—Well, I feel positively certain it was incorrect.

11439. You are not inclined to think from that analysis that the gas has altered in composition?—Not a bit.

11440. I presume you know a paper read by Mr. Dawson which appears in the Quarterly Review of the Geological Society?—Yes, I have seen numerous papers by him.

11441. There is an analysis of Dr. Hewett's quoted there?—Yes.

11442. Which agrees very nearly with mine?—Except that he does not give any illuminating phase of any sort.

11443. But he finds between 91 and 92 per cent. of methane?—Yes.

11444. That being so, why do you refer in your proof to ethane and compare it with the illuminating constituents of Boghead cannel?—Because I take it that Boghead cannel gas—the ethane in a natural state—is a very good illuminant. Methane is not an illuminant at all.

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11445. Are you mistaking that ethane for ethylene, which is the chief illuminant in coal gas, and in a larger percentage in cannel gas, methane being CH_4, ethane C_2H_6, and ethylene C_2H_4?—Yes.

11446. It struck me when reading your proof that you might have confused those two?—I may have done so, but I cannot account for the illuminating phase except by the ethane.

11447. But you are probably aware that methane does give a little light?—True, but I do not consider that hydrogen gives any light.

11448. No, it does not—In that way I always reckon the methane in any ordinary experiment of any sort which I have ever conducted.

11449. But methane, you know, contains gaseous carbon, and gives a slightly luminous flame in an Argand burner?—Yes.

11450. Ethane gives more, but not nearly so much as ethylene, and I think when you compare it with cannel coal gas, it is ethylene you mean. There is no comparison between the illuminating power of your gas and the gas from cannel coal?—No, none whatever. I mean we talk of 12 candle-power at the best; I believe you talk of 40 candle-power, or even higher.

11451. May I draw your attention to this paragraph in your proof; you quote an analysis which was made by me?—Yes.

11452. Then you go on to say: "It is 3 per cent. of ethane which gives the Heathfield gas its conspicuous superiority to the American natural gas as an illuminant. Boghead coal gas, which is, I believe, the highest candle power gas ever produced from coal, has only about 4·7 per cent. of ethane in its composition?"—Yes.

11453. That appears to imply that ethane is the chief illuminant in the gas obtained from cannel? Yes.

11454. Whereas, it is not at all?—No.

11455. Ethylene, of course, and other unsaturated hydro-carbons, form the chief illuminants?—Yes.

11456. So that you cannot compare this with cannel gas?—I was trying to show how we get our illuminant phase in our gas at all, because it has been queried.

11457. Yes, I have no doubt you are right that the ethane does give it—I really am taking it absolutely from your analysis. In the way I look at it, ethane is the only thing which can give it.

11458. (*Sir George Armytage.*) That is the only thing that gives the illuminating element?—Yes.

11459. (*Professor Dixon.*) How did you determine that 12 candle-power, with a Batswing burner?—Under a photometer in the ordinary way.

11460. Did the same gentleman do that who did this analysis you have referred to?—No, it was done by Mr. Watts, our engineer in charge there, who is a gaslight and coke engineer.

11461. What illuminating power then did he find in an Argand burner?—I could not tell you; I do not know; it is only the naked Batswing that I know at all.

11462. Of course you know that the London gas is tested in what is called a London Argand burner, and not in a Batswing burner?—Yes, I know that.

11463. I had only the opportunity at Heathfield of looking at the flame, and I had no photometric apparatus there, but I should doubt very much whether it gives a 12 candle-power in a Batswing, or anything like it?—I am only talking of tests given me by Messrs. Masterman, of Victoria Street, and by Mr. Watts.

11464. They did it at Heathfield station, did they not?—No, at Victoria Street.

11465. How did they convey the gas there?—I understand it was taken in glass tubes. Mr. Dawson dealt with it in that paper which has been referred to—I think it was before the Royal Society—they showed the burning of the gas, and it was at that time that they took the candle power.

11466. Carrying it up in a glass tube?—I think it was in glass tubes.

11467. How big a supply could they carry in a glass tube?—I could not say; I am only quoting as far as the candle power is concerned, and what has been given me by the two men picked for the purpose.

Mr. Richard Pearson.

25 Feb. 1903.

11468. (*Sir George Armytage.*) They bottled it for themselves?—Yes.

11469. (*Professor Dixon.*) As far as you know, the actual test has only been made with the gas conveyed in some small vessel from Heathfield?—Yes, simply.

11470. May I point out to you that that is not a usual way of determining the illuminating power of gas?—No, it is not.

11471. It is not a calculated power, I suppose?—No, except on the photometer. They were testing mantles at the same time that they were testing the gas from Heathfield.

11472. Of course the mantles give a brilliant light; I am not questioning that for a moment; it is the illuminating power with the Batswing that I am talking about?—Yes; I only tell you that they were asked to give a report upon the candle-power, and that was their report.

11473. You are not speaking, then, upon first-hand knowledge now?—No, not at all.

11474. You have no experience yourself of that?—I have taken a good many lights on a photometer, but I have never taken Heathfield gas on a photometer myself.

11475. Then one further question; with regard to the thermal capacity of this gas which you give, is that calculated from the analysis, or is it done practically?—I am referring there to natural gas. Is that the statement you refer to?

11476. Yes. I will read the paragraph: "The comparison of gaseous fuels is approximately as follows: per 1,000 cubic feet at 40 Fahr. at atmospheric pressure, natural gas"—that means, your gas at Heathfield?—No, you must not take it as being our gas. Those are American results entirely in America.

11477. Of course you know the composition of American gas varies considerably in different places?—Yes, I know that. I have an analysis here of many American wells and districts.

11478. Then the table which appears after that refers to your own, does it not?—Yes.

11479. Is that calculated, or is that the result of your work with the gas engine?—That is the result of our work with the gas engine.

11480. That is to say, 12 to 15ft. per h.p.?—Yes; the other, the gas engines, I have worked myself with small power; I have never done 20ft.—I have always been higher—but I put it in here. It is the best, I think, that I have heard of on 1 h.p.

11481. That is to say, 20?—Yes. I mean I have worked up nearer 30 in actual practice.

11482. You are making a holder, I believe, for this gas?—Yes.

11483. In the nature of a brick well?—A brick well of 12½ft. by 75ft. in depth. That is a pressure holder underground.

11484. Have you got that full yet?—No; we are only getting our steel sheets down now. We have it all bricked down and finished; we have had a lot of other work.

11485. May I ask are you going to line that brickwork with iron or steel plates?—Yes.

11486. Then this will be practically an iron or steel holder?—Yes, a pressure holder.

11487. From that, I suppose, you will feed into long pipes to Eastbourne and elsewhere?—Yes, that is our idea.

11488. I understand you to say that you are boring some other wells seven or eight miles away?—Yes.

11489. What depth have you got there?—We are on gas at Mayfield, five miles away, but at Netherfield we are only down 200ft.

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Mr. Richard Pearson.

25 Feb. 1903.

11490. Would you have any objection to giving us the results when you arrive at them ?—I shall be only too pleased.

11491. Will you communicate with the Secretary ?—But if at Netherfield, as I have tried to show in my statement, we strike gas at all, as I believe we shall, it will be the second horizon, because Heathfield geologically is over 400ft. higher ; the sandstone is above the Purbeck where we are starting on the Purbeck at Netherfield.

11492. (*Professor Hull.*) Then you propose to go into the Kimmeridge clay ?—Well, we are into the Portland.

(*Professor Hull.*) Yes, into the Portland.

11493. (*Sir George Armytage.*) Have you finished sections of wells which you have already sunk ?—Yes.

11494. Would you mind letting us have those ?—I shall be pleased to do so.

11495. (*Professor Dixon.*) One question arising out of the question put by Sir George Armytage, is the Purbeck bed in your opinion porous to the gas, or rather to places where you think it is being made ?—At Mayfield, in our deep well at the station where we ought to have hit a quantity of gypsum, we hit a shale full of petroleum, which I think is decomposed gypsum—I may be wrong entirely.

11496. (*Professor Hull.*) That would require very considerable chemical interchanging ?—True, but the formation of the sulphate of calcium, or gypsum, I take it, was from carbonate of calcium.

11497. Well, it might have been, of course ?—If it was from a carbonate your "C" of the carbonate has gone somewhere—it has disappeared somewhere—where has it gone to ? I say it has gone into the methane.

11498. You should not call it decomposed gypsum ?—No, carbonate. I do not know whether you have been to the Sub-Wealden gypsum works, Professor Dixon, but there are large quantities of that gypsum which are absolutely unworkable—miserable slatey-looking stuff full of petroleum. You can burn it, and if you strike it, smells of petroleum come off at once. That seems to me to show that the gypsum bed is a hydro-carbon, or may I call it, a gaseous bed, and below that we get bituminous beds of the Kimmeridge, which are known to be bituminous, and below the Kimmeridge we get the Oxford, which is also bituminous.

11499. But it is not likely that the gypsum has been saturated with organic matter from the underlying carbonaceous beds ?—But that gypsum is not gypsum as we know it at all, it is absolutely a different formation.

11500. But it is sulphate of lime, is it not ?—There is a lot of carbonate still there. They cannot work it in any way.

11501. (*Professor Dixon.*) You know gypsum splits easily, and you can get hydro-carbons through it ?—Yes, true, but it may be held there.

11502. (*Sir George Armytage.*) Are these wells which you have already sunk some depth down ?—Most of them. At Mayfield we are much lower.

11503. They are all of them in what may be called the gas-bearing strata ?—Yes.

11504. Why do you sink them so close together ?—Anything like an area of half a mile or three-quarters of a mile is not close as compared with other gasfields. There it is a matter of a few feet. Our idea was commercial. In the first place it was to get our pipes near that railway station—we have a monopoly from the railway company for 50 years to convey it along their line so that we should not have long expansions and great outlay in respect of pipes.

11505. You say you have had applications from, or negotiations with, people for setting up works, or something of that sort, in the neighbourhood. I suppose they naturally ask you whether you can guarantee this, do they not ?—Yes.

11506. What reply do you give to that ?—Well, we cannot guarantee permanency ; no one can. We can point out that the gas at the Brighton well, after eight years, is as good as the day it was proved, but no one can guarantee permanency.

11507. Do I understand you to say that in America these wells give out sometimes in periods from seven to 15 years ?—Yes, and others, of course, are very much older. But of course the volume from the number of wells that they have got is something enormous in cubic feet ; I have the tables here.

11508. We may take it that the larger the number of wells that are sunk the worse it is for those that are already sunk—every extra well, as it were, takes its proportion of this gas away ?—I do not think so, because a well a good distance off I do not think draws from that same area. In time it would, but the vent that we put down, or that they put down, which is only a few inches, I do not think draws from a great area.

11509. (*Professor Dixon.*) As a matter of fact have you noticed any reduction in pressure in your wells ?—Not in the slightest.

11510. (*Sir George Armytage.*) But then you have only sunk in the aggregate how many ?—We have six producing and nine are going down there.

11511. So far as you know you are covering an area of how many square miles ?—In those six wells which are producing we are working over 200 square miles now.

11512. What area are the American wells working over ?—The Pittsburg wells, I understand, are about the same area ; there are 11,000 wells sunk in America to-day.

11513. (*Professor Dixon.*) But you are not drawing gas from an area of 200 square miles ?—No, I do not think 200 square inches.

11514. (*Sir George Armytage.*) How do you know you are not drawing gas ?

(*Professor Dixon.*) I mean they are only putting pipes there.

11515. (*Sir George Armytage.*) Will you tell me why these pipes are put in such small diameter ?—I take it that when once you get on to the gas horizon the pressure there being great, a small pipe will convey a large volume of gas ; and in boring—in sinking a shaft—it is rather difficult to get down a few hundred yards. In the coalfields of England I do not think you could count 11,000 shafts—I do not know—I mean to say it is a tremendous undertaking. The only way in which you could undertake it at all is by putting down a small boring, and that is by far the best way of getting down to petroleum, or water, or gas, or proving any mineral substance.

11516. But in proportion to cost could you not put down a very much larger pipe which would give you a larger supply at comparatively less cost ?—If the pressure was coming fully from all sides, yes ; but I think our pressure is greatly from below, and if so I do not think it would matter. If the pressure was from all sides the same, it may be it would.

11517. (*Professor Hull.*) I presume it is from the Purbeck beds and from the Kimmeridge clay that you consider these discharges of gas and petroleum are derived ?—And the Oxford.

11518. Oxford clay ?—Yes.

11519. Oxford clay does not contain much bituminous matter ?—Well, it contains some. It has been used to a limited extent, I believe, in Dorsetshire.

11520. I did not know that. In answer to the question put by Sir George Armytage with regard to why you do not put down larger tubes, I suppose you have to line them and telescope them, and consequently they are decreasing in diameter ?—Yes. Our 400ft. decreased to very little.

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11521. (*Professor Dixon.*) Perhaps you may be able to answer this, if not, the geologists can: What is the highest part of this anticlinal arch, or lid, as you describe it graphically, over the gas-holder, whereabouts does the highest part occur?—I think it is very close to a place called Cross-in-Hand. Do you mean from sea level?

11522. (*Professor Hull.*) It is about Tunbridge Wells, is it not?—No, I do not think it is so high there.

11523. (*Dr. Le Neve Foster.*) Cross-in-Hand is higher than Tunbridge Wells?—You mean from sea level. Crowborough is by far higher.

11524. (*Professor Dixon.*) What I want to know is this, whereabouts do you expect the main gas to accumulate?—That is a very difficult point to answer. I take it that that arch is most certainly the big chalk arch which has been washed away.

11525. (*Professor Hull.*) Yes, the chalk has been washed away.—Yes and that was the great arch. *Mr. Richard Pearson.* 25 Feb. 1903.

11526. It was the centre?—Yes.

11527. But the present anticlinal where you are carrying on the borings is shown clearly on the geological map?—May I hand you the book which I referred to of Damon on the Geology of Dorsetshire?—

11528. I see he says "The Oxford clay, like the Kimmeridge, contains beds of inflammable shale, although in less strength than the latter." I know the Oxford clay as it comes from the surface very well. I only wish to congratulate you in having carried out these experiments?—Thank you.

NINETEENTH DAY.

Tuesday, 17*th March* 1903.

PRESENT:

THE CHAIRMAN.

Sir GEORGE ARMYTAGE.
Sir LINDSAY WOOD.
Mr. BRIGGS.
Professor DIXON.
Dr. LE NEVE FOSTER.
Professor HULL.
Mr. MACLAY.
Mr. SOPWITH.
Mr. YOUNG.

The Secretary.
The Assistant Secretary.

Sir ALFRED HICKMAN, called: and Examined.

11529. SUMMARY OF EVIDENCE.

1. The cause at the root of the high charges for conveyance of coals on English Railways is the combination between three great Companies: the London & North-Western, Great Western, and Midland.

No one company can reduce any rate without the consent of the other two, and therefore it often happens that though one company is convinced that it would pay to reduce a rate it is powerless to do so.

There is, on the other hand, acute competition in facilities for passenger traffic, and great expense is incurred, which the goods and mineral traffic, especially the latter, have to bear.

2. The last half-yearly return of the London & North-Western shews that the charge per passenger train mile was 4s. 8d.; for goods and minerals, 7s. 9d. The cost all round per train mile of all trains, deducting the charges which were exclusively passenger or goods, was 2s. 5·74d., and the charges which were exclusively passenger or goods, as distinguished from mineral, were 6·47d., making together, say, 3s. 0d. per train mile, and deducting the charges exclusively passenger and goods from the mineral train cost leaves it only 1s. 11d.* The return per passenger train mile was only 4s. 8d., while for goods and minerals it was 7s. 9d., so that you have—

	cost.	return.
Per passenger train mile ..	3s. 0d.	4s. 8d.
Per mineral train mile ..	1s. 11d.	7s. 9d.

*See Q. 11858 *et. seq.*

These figures do not pretend to absolute accuracy, because the company's accounts do not give all the details necessary, but it is believed that the general result is fairly stated and no account is taken of the army of porters, ticket clerks and collectors necessary for passenger traffic, or the cost of building and repairing station warehouses, etc., and the much greater expense incurred in running passenger trains on account of the extra speed. *Sir Alfred Hickman.* 17 Mar. 1903.

3. The passengers in a Scotch first-class sleeping carriage with every luxury are carried at forty-five to fifty miles an hour, taking into account the weight of the car, at about ½d. per ton per mile, or less than cost.

Four trains start at the same moment, and twelve others within less than half-an-hour of each other every day, London to Glasgow.

If the railway companies would agree together not to run unnecessary trains starting and arriving at the same time between the same stations, and would allow return tickets to be available on either of the lines running between the same stations, greater accommodation might be given to the public and sufficient saving effected to permit of a large reduction in mineral traffic.

4. A great deal has been said about trucks of larger carrying capacity; but the English railway companies are singularly slow in realising the large saving that may be effected by them.

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Sir Alfred Hickman.

17 Mar. 1903.

The Chairman of the London & North Western said a month ago that his company had actually got 112 twenty-ton wagons at work.

Wagons are now advertised by the Leeds Forge Company made entirely of steel carrying 30 tons with a tare of 12 tons 16 cwt.

The 10-ton ordinary wood wagons weigh 5 tons, 14 cwts, that is, three weigh 16 tons 12 cwts., so that the saving in tare per 30-ton wagon is 3 tons 16 cwts., or nearly thirty per cent., *i.e.*, on 12 tons 16 cwts.

But the Chairman of one of the great railways told me he had made experiments with a 20-ton bogie wagon as compared with an ordinary 10-ton truck, and the one took no more power to draw it than the other, so that twenty tons of coal are conveyed in one truck at half the cost of conveying them in two.

The total weight that can be carried in a train is generally limited by the length which can be dealt with at different sidings.

The length over all of a 30-ton wagon is 38 feet; the length of a 10-ton wagon is 19 feet.

Taking a train at 570 feet, the train of 10-ton trucks would convey 300 tons, whereas a train of the same length in 30-ton wagons would convey 450 tons. Given the engine sufficiently powerful to draw 450 tons, that amount could be carried at the same cost as the 300 tons.

The average load of a truck of goods is about 2 ton 4 cwt.; at 2d. per ton per mile, this would give 4·4d. per truck per mile; but 30 tons of coal at ¼d. gives 7½d. per truck per mile, and undoubtedly would give the railway a much better return, and an immense stimulus would be given to all the manufacturing industries of the country if their coals were carried at ¼d. per ton per mile.

But Lord Stalbridge, at the General Meeting, said that the average consignments of coal are only 17½ tons.

The reason of this is obvious, the trader gains nothing by giving larger consignments. He pays precisely the same per ton per mile whether he consigns 6 tons or 600 tons.

Let railway companies give special rates for full train loads and for 30-ton truck loads, and they will soon find that the traders will avail themselves of them. He said also that the screens and weighing-machines at the collieries were only constructed for 10-ton wagons. Even if the traders were allowed only a portion of the saving to the railway companies of train loads and consignments in 30-ton wagons, the screens and weighing-machines would soon be altered.

Some time ago I was starting an entirely new traffic on one of the great railways, amounting to over a train load per day, and I offered to provide 25-ton bogie wagons for the traffic if the company would allow me half of what would be the saving in the tare. They refused to allow anything, and the traffic is carried to-day in the old 10-ton wagons.

The average train loads on the four great English railways were lately given by the General Manager of the North Eastern Railway, as under:—

	Merchandise.	*Mineral.*
London & North Western ..	45	100
North Eastern	44	92½
Midland	40	90
Great Western	32	80

whereas on the Baltimore and Ohio Railway the average train load is 1,000 tons; maximum, 1,800; minimum, 800.

It is not surprising that under these circumstances the average charge there for minerals and goods of all sorts is one-fifth of a penny per ton per mile, and the charge on English railways from five to ten times as much.

It is stated that the North Eastern Railway Company have just completed a train consisting of 25 wagons, each carrying 40 tons, so that the load is 1,000 tons; the tare is 400 tons, and to carry the same weight in their ordinary wagons 100 would be required, with a tare of 625 tons, or 56 per cent. more than the 40-ton wagons, and the length of the train would be nearly double.

The tare of the latter is 62 per cent. of the paying load against 40 per cent. in the 40-ton wagons.

Supposing this train carrying 1,000 tons costs double as much in haulage as the ordinary average train, which is believed to be an ample allowance, it would carry the coals at less than one-fifth the present cost.

I ought to say that some of the members of the Mining Association of Great Britain, while agreeing with my evidence on the whole, do not agree with my proposals as to the larger trucks.

11529.* (*Chairman.*) Will you state your qualification?—I am M.P. for Wolverhampton West. I am an iron-master by trade.

11530. Are you connected with collieries as well as with the iron trade?—Yes.

11531. I understand you wish to deal with the question of the charges for conveyance of coal on English railways. You believe that the root of the high charges, as you describe them, is a combination between three great companies, the London and North Western, the Great Western, and the Midland?—Yes.

11532. You think that the combination of those companies affects the question of charges. Do you mean in a particular district, or throughout the country generally?—The ramifications of those three great companies extend so widely and so far, that I believe they affect charges generally throughout the Kingdom.

11533. I only ask you that because in your proof you limit yourself to those three companies?—They affect all the Midland district. I do not know whether they go as far as the North Eastern; probably the North Eastern are independent, and work on their own lines.

11534. You go on to say: "No one company can reduce any rate without the consent of the other two"?—That is so.

11535. "And therefore it often happens, that though one company is convinced that it would pay to reduce a rate, it is powerless to do so"?—That has happened in my experience more than once. I have applied to a particular company to reduce a particular rate, and have been told that the application is favourably entertained, and it has been practically admitted that it would be advantageous to reduce the rate, but at the same time I am told that the consent of the other companies must be obtained, and then afterwards I am told that the consent has been withheld, and therefore the rate cannot be reduced.

11536. You think that applies to the consent of these particular companies, and that it was not founded upon any statutory obligation to give the same rates to everybody?—Oh no.

11537. You think that had nothing to do with the question?—No; the reduction in the rate would be general, of course.

11538. Therefore the particular company in your particular case, thinking that it might be advantageous to make a reduction was not limited merely by its combination with the other companies to which you refer, but also by its statutory obligation to give the same terms to everybody else?—Naturally if the rate had been reduced to me it must have been reduced to everybody else but I do not think, in the cases I have referred to, that was the actuating consideration. For example, supposing I apply to the Great Western and they are satisfied that it would be to their advantage to reduce a rate, they apply to the North Western, who might say "Oh yes, we have no objection;" then they would go to the Midland, but the Midland might say "Oh no, we shall not get the traffic if we consent to the reduction, and on the other hand it will compete with other traffic which we have got, and we think it will be disadvantageous to us; we will not consent."

11539. Quite so; in other words, with regard to the reduction of a rate to a particular firm or in a particular district, the competition is such that it would affect the rates throughout the country?—No doubt it would.

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11540. You go on to draw a comparison between the facilities for passenger traffic and the great expense which is incurred, and you compare that with the goods and mineral traffic, and apparently your view is, to put it shortly, that the passenger traffic does not pay, and that the goods and mineral traffic have to bear the loss that is incurred?—I think it is quite evident that the passenger traffic does not pay to anything like the same extent.

11541. Would you develop that a little, because it is interesting?—According to the London and North Western last half-yearly returns, the receipt per passenger train mile was 4s. 8d. and for goods and minerals it was 7s. 9d. Taking the accounts and analysing them, there are certain charges which do not apply to mineral traffic at all which are exclusively either goods or passenger.

11542. Will you kindly give us an instance?—For example, carriage and wagon repairs, £348,000. Now in all mineral traffic on the London and North Western the wagons are supplied by the freighter, and not by the company, so that that charge would not come upon the mineral traffic at all.

11543. You say the wagons are supplied by the trader?—For mineral traffic they are supplied by the trader, and therefore the charge for repairing wagons does not come upon the mineral traffic at all.

11544. Then what does it come upon?—It comes upon the passenger traffic and upon the goods traffic.

11545. But the cost of repair and maintenance of the wagons would not fall upon the passenger traffic, would it?—The cost of the carriages falls upon the passenger traffic, and of the wagons upon the goods traffic.

11546. Quite so. I do not follow, therefore, why you debit the charge to the passenger traffic?—I do not debit it to the passenger traffic, but I deduct it from the mineral traffic.

11547. (*Sir George Armytage.*) You put the passenger traffic and the goods traffic together?—Yes.

11548. And then you compare them with the minerals?—That is so.

11549. (*Chairman.*) Then you make out that the cost all round per train mile, if I understand your statement, is about 3s.?—That is so.

11550. That is goods and passengers and minerals?—Goods, passengers and minerals.

11551. Then you go on to make a further calculation?—Yes, the cost all round per train mile of all trains deducting the charges, which were exclusively passenger or goods was 2*s.* 5·74*d.*

11552. Yes, then you add to that 6·47d.?—6·47d, which are the charges exclusively applicable to the passengers or goods as distinct from the mineral traffic.

11553. Yes, I see you distinguish it?—So that that would make the cost per passenger mineral and goods train mile 3s.; then deducting the 6·47d. from the 2s. 5·74d. it brings the mineral traffic down to 1s. 11d. So that in fact per passenger train mile the cost is 3s. and the return is 4s. 8d.; per mineral train mile the cost is 1s. 11d., and the return is 7s. 9d.

11554. (*Mr. Briggs.*) The return is there shown of goods and minerals, is it not?—Yes, of goods and minerals.

11555. I mean you do not know what the minerals are apart from the goods?—No, we have no means of separating them.

11556. (*Chairman.*) You have no means of separating the cost?—No means of separating the return. But I think it is a matter of common knowledge that a mineral train can be loaded, and is generally loaded, to a greater capacity than a goods train. It might always be, according to my contention.

11557. That is to say, that it carries more tons?—It carries more money, or it might easily carry more money.

11558. Well, it carries more tons, you mean, to start with?—Yes.

11559. But of course the rate might be different?—Quite so.

11560. You mean you think it carries also more money per wagon?—Undoubtedly. A mineral wagon is always practically loaded to its full capacity, whereas the ordinary load of a goods wagon is about one-fourth or one-fifth of its capacity—I think the average is about one-fourth.

11561. Have you taken into account in your calculation the fact that the mineral wagon is not loaded both ways?—That is so, no doubt.

11562. But would not that affect the earning?—No doubt you have to take it back empty.

11563. Therefore you would have to divide its earnings by two, would you not?—Well, I suppose it does not cost quite so much to convey an empty truck as a full one, but nearly so. Still, there is a very large margin, as you will perceive, between 1s. 11d. and 7s. 9d. and there is still a large margin supposing you double the 1s. 11d. and make it 3s. 10d.

11564. Have you made any interesting calculation on this basis, taking the London and North Western figures to which you refer, and making an approximate guess as to how these figures work out compared with the actual result?—I do not quite follow the question.

11565. I will try and explain it. You start with an estimated cost of 1s. 11d. as being the cost per mineral train mile?—Yes.

11566. By a process of exhaustion, you arrive, at all events, at these two figures: that you estimate the cost of a passenger train mile to be 3s. and you estimate the cost of the mineral train mile to be 1s. 11d.?—Yes.

11567. You estimate the receipts per train to be as you have described them, namely, 4s. 8d. and 7s. 9d. respectively?—Those are the actual figures. They are not estimated, but the actual figures.

11568. Yes, but in the case of the minerals it includes the goods?—Yes.

11569. That is to say, the 7s. 9d. includes goods as well as minerals?—Yes.

11570. It would not be difficult to make an approximate estimate of the expenditure of money based upon these figures and compare it with the actual expenditure?—No.

11571. As it presents itself to me, at all events, this appears to point to a profit, which is not reflected in the dividends paid?—No, on the contrary. I do not profess to absolute accuracy, but so far as the accounts furnish material, these are the digest of the actual figures themselves; for example, the total return for goods and minerals is so many hundreds of thousands of pounds, and there are so many miles run, that is to say, it is so much per train mile; and the returns are so many hundreds of thousands of pounds and so many miles run, that is to say, the return is so much per train mile. Those are the actual figures, there is no doubt. I may be wrong as to my 6·47d.; I think it is under-stated very much, because obviously a passenger train costs very much more than a goods train or a mineral train, and a mineral train is not tied to time, but runs about 15 miles an hour.

11572-3. That does not lessen the cost of it, does it?—I have always understood that the cost of a train is in proportion to its speed.

11574. Just think for a moment. Do you think that, for instance, the driver, fireman and guard get no more wages for 10 hours than they do for five hours?—They do undoubtedly.

11575. That would add to the cost if you took longer on the journey?—I mean to say that an engine-driver who drives the Scotch Express gets more wages than a man who runs a mineral train. Of course the additional cost would not be in wages so much

11576. What is it in if it is not in the wages?—In the first place the wages are very much more, because there is an army of porters to attend to the passenger trains: when you arrive at Euston, say, every passenger has a porter waiting for him. There is nothing of that kind in the mineral traffic. Then in your sleeping-cars, and so on, you have attendants to wait upon you, and there is no doubt the charges in a passenger train are very much higher than in a goods train: you have the ticket collectors, the men who give the tickets out, the station-masters, and all those sort of people all connected with the passenger traffic.

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Mr Alfred Hickman.

17 Mar. 1903.

11577. Do you think you have included the cost of cartage and delivery in these mineral receipts?—No, I think not. There is no cartage and delivery in the mineral receipts

11578. But you spoke of goods just now, because the goods are included in them, according to your own statement?—I am not quite clear as to that. I think it is probable they may be, but I do not think it is stated very clearly. It is certainly not calculated in the 7s. 9d. because there is no cartage on the mineral traffic.

11579. No, I understand what you say about mineral traffic, but it does not follow that there are no other expenses, although no cartage?—There are some other expenses: of course, there is the shunting: but the expenses are comparatively very very small

11580. By the way, with regard to that, you have spoken as though there were competition in facilities for passenger traffic. Do you not think there is competition in facilities for mineral traffic?—Yes. That brings me to a point which I should like to mention. Four men come to my works every day, who are all educated persons, and who earn, and I daresay receive, very good salaries They come and ask if we have any freight for so and so, and for so and so—anywhere Well, that is competition in facilities, but it does not benefit me one farthing. Still, it is a great cost to the company, but it is a cost which they incur in competition with one another, by which the trader gets no benefit whatever.

11581. You think that money would be saved if competition could be abandoned?—Certainly, competition of that kind.

11582. I agree, but that was not what I was referring to in speaking of facilities. Have you never seen in your travels, miles and miles of sidings that are provided by the railway companies for coal? I do not know whether you ever go to Peterborough, because that is a place I pass through sometimes?—Peterborough is a place I do not know.

11583. But every company has similar facilities?—In my experience the sidings are provided by the trader.

11584. Not on the railway, are they?—Of course, when they deliver coal in London and towns of that kind, they must provide coal sidings, undoubtedly.

11585. Yes, or at any point of distribution or concentration?—Yes, certainly; but you would scarcely compare that with the great stations which are required for passenger traffic.

11586. I am not sure that I should not. Really, are there not facilities provided? It is perhaps not a very important point, but you indicated in your evidence that there was competition in facilities as regards passengers but not as regards minerals?—Of course, undoubtedly there are some facilities for minerals.

11587. But does not the provision of a great storage yard for minerals correspond with what you would consider to be a great warehouse for goods, or a great station for passengers?—Undoubtedly it has some relation, but not much.

11588. But you know that it costs a great deal of money?—Yes, but if you consider that a single pair of rails will accommodate a twenty-ton wagon, whereas the same amount spent in a great warehouse would not go far——

11589. We shall come to the twenty-ton wagon. I am afraid you are imperfectly informed as regards the cost to some companies, at any rate, if these are your views as regards the competition with respect to facilities?—I admit freely that there is cost in coal sidings, but the cost per ton has no relation whatever to the cost per ton as regards warehousing for goods—that is perfectly obvious, I think—or as regards passenger traffic. It cannot possibly have any relation to it, when you have only to provide just the rails and turn-outs.

11590. But the rates are not the same per ton, either?—Well, it is very curious that they approximate very nearly.

11591. The rates per ton?—Yes.

11592. Of coal to goods? Would you give us an instance?—Yes, I will give you an instance. I was travelling the other day by a dining-car, and I counted up the seats, and I found there was room for 18 persons if it was all filled; and I asked what the weight of the car was, and I was told it was 38 tons. If you work that out at the first-class fare you will find it comes to just under 1d. per ton per mile, but supposing, as is usually the case, only about three-fourths of the seats are filled, it would work out at ¾d. per ton per mile, and that approximates pretty nearly to the ordinary coal rates. My average coal rates of which I have a list here, work out about ·82d.

11593. That is ·82d. per ton per mile?—Yes.

11594. Could you tell us the distances?—From 120 miles down to 25 or 30 miles.

11595. And more of 25 and 30 miles than 120, I suppose?—No, I do not think so. Our large traffic is in London, and that is over 100 miles.

11596. Does that amount to ·80d.?—Our London rate is ·68d.

11597. That is probably the highest?—Oh dear no. We have plenty of rates that are higher.

11598. For that distance?—Yes. Another London rate is ·69d. I have a Gloucester rate of ·78d., a Cheltenham rate ·80d., an Oxford rate ·70d., and so on.

11599. You do not suggest that those are the lowest rates per ton which are charged?—The lowest rate I have is where we do very little traffic, and that is to Bath; that is ·58d.

11600. What distance is that?—111 miles. But the average works out at ·83d. I have got one calculation of ·82d., and one of ·85d., and I have averaged it at ·83d., the one set of stations is at ·83d., and the other at ·85d.

11601. Then it is mainly short distance traffic, because I thought you said the London rate for the distance was the lowest?—The Bath rate is the lowest for the distance. The London rate is ·68d.

11602. You think there are too many passenger trains run, or at all events that great economies could be effected if arrangements were made between the Companies?—I have no doubt of it.

11603. You illustrate it by showing that four trains start at the same moment and twelve others within less than half an hour of each other every day. I suppose you have London in mind?—From London to Glasgow. Of course the London traffic to Glasgow is sometimes very crowded; but taking the journey from Wolverhampton to London, they start two trains at the same time within one hundred yards of each other, and they arrive within a quarter of a mile of each other and within a quarter of an hour of the same time.

11604. Do they stop on the way?—Well, the fast trains stop once between Wolverhampton and London.

11605. I meant really on the route; do they serve different districts?—No; the Great Western stop their trains at Birmingham, and the London and North Western stop their trains at Birmingham; they do not stop between London and Birmingham at all.

11606. Therefore they serve precisely the same route?—Absolutely.

11607. That is not so in the case of the Glasgow trains which you refer to?—Oh no, not to the same extent. It appears to me that if they agreed together to run trains at alternate times—convenient times—and allowed the return tickets to be available by both lines, the facilities to the public would be greatly increased and the cost to the company would not be increased; and if they ran fewer trains the cost would be very much diminished—fewer trains might give more facilities.

11608. You think the facility of being permitted to return by any route would be valued by the public?—Unquestionably.

11609. (*Professor Hull.*) Do you know whether any attempts have been made by these competing companies to bring about some arrangement of that kind for passenger traffic?—I have never heard of any.

11610. Well, someone must begin, I suppose?—I believe it was done on the South Western between Portsmouth and London: I am not sure that it is being done now, but it was at some time done between London and the south coast.

11611. I refer to the passenger trains to the north?—I am not aware of any. I think the passenger trains between competing points might be reduced by at least one-fourth, giving greater facilities than at present to the public.

11612. Yes, by a proper arrangement between themselves?—Yes, of times, and so on.

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11613. (*Chairman.*) Of course that would involve their agreeing to run certain trains at certain times?—Clearly.

11614. I understand you; I am not disposed to quarrel with that view at all. But I see you still contemplate that this saving shall reach the pockets of that impoverished class who deal in mineral traffic?—The point of view which we are dealing with to-day is how mineral rates are to be reduced.

11615. Quite so.—That is my humble contribution to the controversy.

11616. But your would not say that the dividends paid by railway companies are very excessive?—Certainly not as a railway shareholder.

11617. Now we come to this interesting question about the larger trucks. Obviously you have given some attention to this question?—Yes.

11618. By larger trucks I mean the largest kind you mention, namely the 30-ton trucks. First, you think that their adoption is practicable, do you?—Yes.

11619. I mean for a considerable quantity of the general traffic?—Undoubtedly—that is to say the mineral traffic.

11620. Yes, coal traffic. You base your estimate of the saving to be effected, as far as I can see, upon these two points: first, that you could get a greater amount in a given length of train: and, secondly, that you would generally reduce the dead weight?—Exactly.

11621. Those are the two main points?—Those are the points.

11622. Would not that be in a way an advantage to the trader as well as to the railway company?—I think so.

11623. Especially where he provides his own wagons?—Exactly.

11624. But have you seen much movement in that direction on the part of the traders?—I will tell you my own personal experience. I was opening up a new traffic, about a 60 miles run, and I offered to one of the great companies to guarantee two full train loads per day, Sundays included, and we arranged a rate accordingly: the rate having been arranged it occurred to me that a great saving could be made by having larger trucks and running them on bogie wheels. I went back to the general manager and said to him: "Now I have to provide wagons for this traffic, and if you will help me by giving me some inducement I will provide entirely new 25-ton or 30-ton bogie trucks." "Oh," he said, "We do not care what trucks you provide—provide what you like." I said "It will be a very large outlay for me to provide new wagons for this traffic, and surely I ought to have some of the saving." He said "But we do not consider there will be any saving." "Well," I said, "Sir Henry Oakley told me he had made an experiment with the draught of a 25-ton bogie wagon as compared with the ordinary 10-ton trucks and so far as he could find there was no more traction required, taking a run all through, with the one than with the other; surely then there must be a great saving." He said, "We do not think so." I said "But take the tare alone; that is obviously demonstrable." "Well," he said, "It may be, but we do not care." I said, "If you will give me half what you will save in the tare, I will provide entirely new rolling stock for this traffic." He said, "We will not give you anything." I said, "I will see you hanged before I provide new wagons—you will take the old ones."

11625. From what you say, would the cost of providing wagons for a given load, say 500 tons of coal if you like, be greater with the larger wagons than with the smaller ones?—I am not sure, but in this case it undoubtedly would.

(*Sir George Armytage.*) That is to say, larger per ton of coal?

11626. (*Chairman.*) Per ton of coal?—I am not sure that it would.

11627. But then you would have been put to no additional cost, assuming that you had to add to your stock for the new traffic?—Yes, but as a matter of fact I bought a great lot of second hand wagons which were very cheap, and I did make a saving. I am not sure whether there would be an actual saving or not; it is a question which I have not considered, and I must apologise for that.

11628. (*Professor Dixon.*) A steel wagon would be dearer, would it not?—I think it would; but I really am not prepared to say. I think the excess of cost would be very easily made up by the saving which would take place; and I think the trader would cheerfully deal with the excessive cost if he were allowed a fair proportion of the saving.

Sir Alfred Hickman.

17 Mar. 1903.

11629. (*Chairman.*) I am rather inclined to agree with you, if I may venture to say so; if he had a little more experience of the larger wagons. But, I think, probably you may have seen correspondence in the newspapers from apparently authoritative sources representing coal traders who do not exhibit a very favourable sentiment towards the change?—I think everybody is against any change who has got a lot of old wagons which they think will be thrown out of use.

11630. But they are always building new wagons?—Exactly. Still I am quite satisfied that if the railway companies said now, "Anybody who will send their traffic by 25-ton wagons shall have it at so much per cent. off the ordinary rate," there would be a good many 25-ton wagons run, and very quickly.

11631. According to that, there is no advantage to the trader in having the larger wagons?—At present there is none.

11632. And there would be none then—*qua* larger wagon—only the rate?—Precisely: that is the point.

11633. But I thought you attached importance to the fact that the larger wagons would be more convenient for loading and unloading and would occupy less siding room, and if they occupied less sidings on the railway they would occupy less sidings on the colliery company's part?—Yes, and they would take less shunting; you would have one wagon to shunt instead of two or three. Undoubtedly, I think they would be more convenient all round.

11634. Yes, but you think that the only inducement which can bring home to the coal traders or coal merchants the advantage to them is some reduction in the rate?—They will never be adopted until there is a reduction, I am quite sure.

11635. Well, do not put it quite so high as that because there are some now coming into operation?—On behalf of the traders? I am not aware of any. There may be; of course I do not dispute your statement.

11636. When you say, "on behalf of the traders," at any rate carrying traders' goods?—Oh yes, the railway companies are making tentative efforts in that direction, no doubt; but, obviously, when a coal merchant wants a supply of coals it is always more convenient for him to have 10 tons in a truck rather than 25 tons, and he would rather have 10 tons if the rate is the same; but if the rate is 25 per cent. less, if he can save 3d. or 6d. on the rate he will say "send me 25 tons."

11637. Well, would he?—Yes, I think so, to a large extent, at any rate.

11638. Because we hear from time to time that one of the difficulties in getting wagons back is to get them unloaded?—Yes.

11639. And that they take several days in unloading even a 10-ton wagon?—Yes.

11640. How long therefore they would take to unload a 30-ton wagon I do not know. In addition to which you will observe this: never mind about the figures being mere guesses, but if it takes a week to sell the coal and therefore a week to unload a 10-ton wagon, if it took anything like the same time to unload a 30-ton wagon you would have the equivalent of two wagons waiting there all that time?—The practice in our district is that if a truck is not unloaded in 48 hours there is, I think 1s. per day charged, or 6d. per day.

11641. 6d. per day, perhaps?—6d. per day, is it? That is for siding room.

11642. Yes, but still that does not overcome the difficulty of the merchant having to sell his coal before he can unload it?—Of course it only shows that the larger truck will not be adopted unless there is some considerable advantage given by the railway company for its adoption.

11643. Then it would be no advantage to the railway company?—Well, I think the advantage would be divided, and I do not think really there ought to be any advantage to the railway company, because I think the rates are already too high.

11644. You are now speaking of coal?—Yes.

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Sir Alfred Hickman.

17 Mar. 1903.

11645. And your view is that all the profit of the railway company is made out of coal?—I think a very unfair proportion of it is.

11646. Then you speak about engines sufficiently powerful to draw 450 tons. Well, there are a good many engines more powerful than that, are there not?—I should think so, certainly.

11647. Then as to a truck of goods: you say the average load of a truck of goods is about 2 tons 4 cwt.—Yes.

11648. I am not sure that you do not put it too high?—I put it at the highest I have seen.

11649. Then you estimate that that at 2d. per ton. will give 4·4d. per truck per mile?—Yes.

11650. But 30 tons of coal you say at a ¼d. gives 7½d. per truck per mile?—Yes.

11651. "And undoubtedly it would give the railway company a much greater return?"—Yes.

11652. "And an immense stimulus would be given to all the manufacturing industries of the country if their coals were carried at a ¼d. per mile per ton. Have you not left out of account the fact that the wagon goes back empty?—That is so, there must be undoubtedly some reduction from the calculation on that account.

11653. Then you refer in your statement to Lord Stalbridge at the general meeting having said that the average consignments of coal are only 17½ tons?—Yes.

11654. And you say "the reason of it is obvious: the trader gains nothing by giving larger consignments: he pays precisely the same per ton per mile whether he consigns six tons or 600 tons."

(*Professor Hull.*) I do not quite understand what "consignment" means there.

(*Chairman.*) I am only guessing, but I think Lord Stalbridge meant larger consignments in this sense: you would speak of a number of parcels sent to different destinations, each of them having a separate consignment, and he meant therefore that the number of invoices, if you like, divided into the total, would give a number of separate destinations or invoices. Of course I think on the words it would look as though Lord Stalbridge had been seeking to enforce this point, that if a consignment of coal, or if the larger consignments of coal, did not exceed 17½ tons there would be no advantage in having the 30-ton wagons.

(*Witness.*) But surely that is not sound argument, is it; because if the average is 17½ tons, some must be considerably more, and if, say, five consignments out of ten are 25 tons, and the others are 7, 8, or 10 tons, surely the man who sends his 25 tons in one wagon ought to get a lower rate. It will answer the company's purpose to encourage the larger consignments; they can carry the larger consignment much cheaper, and I submit they ought to give a lower rate for it. Lord Stalbridge went on to say: "It may surprise you to learn that with our heavy coal traffic our average consignment is only 17½ tons, and the consignments vary from lots of 2 tons 14 cwt., to close upon 1,000 tons for shipment." But I mean to say a man who sends 2 tons 14 cwt. of coal in a truck ought to pay a higher rate for it undoubtedly.

11655. He would not like to do that, would he?—He might not like it, but it is only fair that he should do it. He gets double the value for his money, that is to say, he gives twice the trouble, and puts the railway company to twice the expense, and surely he ought to pay more in proportion.

11656. (*Sir Lindsay Wood.*) Is it a fact that he does not pay more?—Well, I should think for 2 tons 14 cwt. undoubtedly he ought to do so. I understand that there is a provision in all railways, that there is a minimum of 4 tons; but we may apply the same theory to the 4 tons rate; a man who sends 4 tons ought to pay more than a man who sends a full truck load, surely.

11657. (*Chairman.*) Then you think it would be an advantage for the railway companies to give special rates for full train loads?—Certainly.

11658. You think that if they would give special rates also for 30-ton truck loads they would soon find the traders avail themselves of it?—I absolutely believe that.

11659. Of course that would apply to a trader who could use or pay for 30 tons at a time?—Quite so.

11660. But the bulk of the traffic is done in smaller parcel than that?—Yes, but I think the bulk would be done in the larger parcels if there was any advantage in it A coal merchant would make an effort to take 30 tons instead of taking 10 tons if he got something for it.

11661. Yes, but it is his customer?—Oh no, it is the coal merchant who receives the consignments.

11662. I quite understand it is the coal merchant who receives it in the sense of being responsible for its transit, and so on, but when he gets the truck to station A he is then dependent upon his customer as to what time it gets unloaded?—I think the bulk of the coal traffic is carried on in this way, that the coal merchant has his place of business at the station, and he receives a truck and portions it out amongst his customers, a ton to one and a ton to another. The customers who will buy a truck load at a time are limited in number.

11663. Then you give us the average train loads of four great English railways.

	Merchandise.	Mineral.
London and North Western - -	45	100
North Eastern - - - - -	44	92½
Midland - - - - - -	40	90
Great Western - - - -	32	80

These were the figures given by Mr. Gibb were they not?—Yes.

11664. (*Sir George Armytage.*) When?—A few weeks ago. He made a speech; I am not sure whether it was at the general meeting, but it was published in all the papers. I think I have it here.

(*Sir George Armytage.*) He read a paper at the Statistical Society.

11665. (*Chairman.*) Then you contrast these small loads of 80 to 100 tons per train with 1,800 tons on the Baltimore and Ohio, with 800 tons as a minimum, and 1,000 tons as an average?—Yes.

11666. You say, "It is not surprising that under these circumstances the average charge there for minerals and goods of all sorts is one-fifth of a penny per ton per mile and the charge on English railways from five to ten times as much." Well, it is not quite comparing like with like, is it?—There are no doubt allowances to be made for length of haulage and so on, but still I think after all allowance is made, there is a striking discrepancy.

11667. The difference is too great?—Yes.

11668. Then you say that the North Eastern Railway Company have just completed a train consisting of 25 wagons each carrying 40 tons?—Yes.

11669. "So that the load is 1,000 tons, the tare is 400 tons, and to carry the same weight in their ordinary wagons 100 in number would be required, with a tare of 625 tons, or 56 per cent. more than the 40-ton wagons, and the length of the train would be nearly double." Is it quite clear that they will hold 40 tons of coal?—It is so stated.

11670. So that they are capable of carrying a load of 40 tons?—It is stated that they actually hold it. The wagons are 40 feet long, 8 feet wide, and 8 feet 2 inches from the rails.

11671. Then you say that some of the members of the Mining Association of Great Britain, while agreeing with your evidence on the whole, do not agree with your proposals as to the trucks. There is a difference of opinion I understand, amongst the colliery people?—There is. Some of the colliery people do not care to face the alteration of their screens, sidings, turntables and weighing machines, and the expensive provision of larger trucks.

11672. Would the alteration of the screens necessarily be a great cost?—Undoubtedly.

11673. It is a question of raising the height, is it not?—In some cases. I think it would be less a question of raising the height of the screens: the coal tips I am told are a great difficulty.

11674. You mean the coal tips for the wagons after transit?—Yes. In my own case I do not think we should have much difficulty with them. I think my screens are high enough to take the wagons, so that I do not think we should find any difficulty.

11675. Would you have any difficulty in your iron-works in emptying or dealing with larger wagons?—No. We have a few 25-ton wagons running.

11676. And you find them satisfactory?—Most satisfactory. They get round the curves, which are very sharp indeed.

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11677. They have a longer wheel base, have they?—No, they are bogie wagons, so that they run round the curves much better.

11678. And you have no turntables, or anything of that sort?—No, we have no turntables. Of course there is the difficulty with weighing machines, but I am told that the weighing-machine makers have found some means of dealing with that question at very small expense.

11679. That is rather interesting; you mean adapting or altering existing machines?—Adapting existing machines.

11680. In order that they may weigh the whole of the wagon at once?—Yes, instead of weighing it twice. I am told it is done very readily and at a comparatively small expense.

11681. (*Sir Lindsay Wood.*) Is not the chief objection to these large trucks on the part of the collieries which are shipping the better class of coal, such as house coal?—The chief objection I have heard is on account of South Wales and some parts of Lancashire.

11682. What is the objection due to?—It is as to the tips into the vessels, and so on.

11683. Is there no objection to them on account of the rather larger breakage and the depth of fall in loading the wagons?—No, I do not think so; I have not heard of it. These North Eastern wagons are all self-emptying wagons; the coal falls from the bottom in the North Eastern train I referred to.

11684. But it is breakage in the loading that I was rather referring to, when dropping from the screens into the wagons, because it has further to fall?—Yes. I do not think the wagons would be very much increased in height. The chief increase is in the length of the body, so that practically the height that they would fall would not be materially increased: it would not be increased so as to break the coal to any extent.

11685. I think the North Eastern 20-ton trucks are nearly 18 inches deeper?—Are they so much as that? You know more about it than I do.

11686. Of course a great objection on the part of the colliery owners is the large cost that many of the old plants will require to have expended upon them in order to get them to a suitable height?—Yes.

11687. (*Mr. Maclay.*) Do I understand that it is a custom of traders to supply their own wagons on the London and North Western line?—Yes.

11688. Does that apply to all traders?—Yes.

11688.* Do the London and North Western Company refuse to supply wagons?—As far as I know they refuse to supply wagons for mineral traffic.

11689. Of course that does not apply over the country generally?—The North Eastern supply all wagons, but the London and North Western do not supply any as far as my knowledge extends, and I believe I know.

11690. So that, if you had not wagons of your own, you could not carry on the traffic?—Quite so. The Midland Railway partly supply wagons and partly their traders, the London and North-Western wagons are entirely traders' wagons, and so are the Great Western wagons, I believe.

11691-2. Then do you take the view that it is better for a trader to supply his wagons than a railway company?—I think the ideal system would be that the railway company should supply them, because obviously they might make use of the return empties, which they cannot do when the trader supplies them.

11693. Yes, that is to say in that case you do away with the single run?—Quite so.

11694. You have the benefit of the double run?—Yes to a very large extent.

11695. Has that always been the custom of the London and North Western, do you know?—Yes, I have known them for 50 years, and it has always been the case.

11696. You as a trader would be quite glad to give up wagons?—Yes, certainly.

11697. Do you consider that would be a great economy?—Undoubtedly it would be an economy. I have some experience of the working of that in the Midland Company. When they first started the idea of working their own wagons I sold them all my wagons and they supplied me with wagons. Then if I kept their wagons waiting to be loaded for two or three days, or if after they were loaded I had not got consignments ready for them, they made charges which did not pay me: so I was obliged to supply myself with a certain number of wagons in order to fulfil those conditions; for example, I do not want to stop my pits at three-quarters of the day; I put my coal into wagons to await the next morning when the consignments come, but then the railway companies will not send wagons unless they have got the consignments.

11698. You consider it obvious that it is to the combined interest that the railway company should supply the wagons?—Undoubtedly.

11699. I suppose there is no difficulty, at least for many classes of traffic, in the one description of wagon doing the work, that is to say, you do not require a special wagon for the different traffic?—No, not at all.

11700. (*Chairman.*) Except that you think you ought to have a large wagon?—Undoubtedly the large wagon would not be available for ordinary goods traffic. I mean to say if you have to put 2 tons 4 cwt. of goods into a 30-ton wagon it would be a very wasteful process.

11701. (*Mr. Maclay.*) It would do for carrying limestone, for instance?—Yes.

11702. And other classes of heavy goods equally well?—Yes.

11703. You spoke of being charged siding room 6d. a day. What did you mean by that?—If a truck of coals is consigned to a siding, and the consignee does not unload it within 48 hours, 6d. per day is charged as long as the wagon remains there not unloaded.

11704. Is that charge insisted on?—Yes, it is a charge which is insisted upon.

11705. And which you have to pay?—Yes.

11706. It is for the use of the siding only?—Yes; I have an account sent me every month.

11707. (*Chairman.*) That is after a certain number of days, is it not?—48 hours is the allowance.

11708. (*Mr. Briggs.*) I think that siding charge has been a benefit to the owner of wagons in great measure, has it not?—Undoubtedly it stimulates the consignee to discharge the wagon.

11709. I mean my experience is that the coal merchant has been the chief offender in keeping wagons?—Yes—to keep his stock in.

11710. Most wagon owners would consider that charge an advantage rather than otherwise?—Yes, it has that side to it undoubtedly,

11711. You mention that those larger wagons would be quite unsuitable for some traffic, such as small coal merchants' traffic, consignments of house coal, and so on?—I think they would be suitable for consignments of house coal; I do not see why they should not—where a man is doing a good business.

11712. Where there is a large business doing?—Yes.

11713. If an allowance of rate were made to the coal owner, or the merchant for supplying the larger wagon, that would soon adjust itself, would it not?—Quite so.

11714. Where it paid them they would find a larger waggon?—Yes.

11715. I think you would get over a great deal of that difficulty, would you not?—Yes, no doubt.

11716. But at present, if there be no such inducement in rate, why should a coal owner or anybody else go to the large expense necessary to provide facilities?—That is precisely the point which I wish to make.

11717. It would be possible for coal merchants, if the larger waggon conveyed the coal at a somewhat lower rate, to join in consignments even?—Quite so.

11718. And that would be done, no doubt, very soon if there were a saving?—Yes.

11719. I presume the larger wagons would be very suitable for coke?—Yes, undoubtedly.

11720. And in that case there is very little difficulty with having wagons of any height in reason: I mean they do not go under screens, do they as a rule?—No.

11721. They are loaded by benches?—Yes, they are not screened at all.

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Sir Alfred Hickman.

17 Mar. 1903.

11722. And probably they might be at once adopted for coke?—Yes, to a large extent, no doubt.

11723. And a rebate on such large wagons would be a very valuable thing to ironworks in the Midlands?—Yes, it would be most valuable.

11724. The rate for coke to your works would no doubt average 4s. or 5s. per ton?—More rather than less.

11725. At present that is rather a serious handicap as against the ironworks, which are comparatively nearer?—Yes, most serious. I pay from 30 per cent. to 40 per cent. in railway rates on the cost of every ton of pig-iron that I make.

11726. So that the large wagons would have a particular advantage in running coke trains, we will say from Yorkshire into your district?—Yes, it would reduce my cost very considerably.

11727. And your quantity would be sufficient to enable a coke maker to arrange to send you a train load of wagons, we will say, instead of sending a few wagons as he does now?—Well, we buy 3,000 or 4,000 tons of coke per week.

11728. (*Dr. Le Neve Foster.*) How do we compare with other European countries with regard to our wagons?—I really am not prepared to say.

11729. What remedy would you propose with regard to these railway rates?—What I would propose is this: that railway companies should give special rates for train loads or for large truck loads or for truck loads at all.

11730. It is like everything else in business—when you are doing business in a large quantity you get a reduction?—Yes, but if in the case of the railway company you can do the large quantity at the same price as the small quantity, surely you should charge less per ton for the large quantity than you do for the small.

11731. But how could you endeavour to get the railways to take that view?—I tried very hard indeed when the 1892 Bill was before Parliament, but I could not get the railway companies to adopt it.

11732. Would you advocate anything being done by Parliament?—Most certainly. I think the Committee made a great mistake in not insisting upon special rates for train loads and truck loads.

11733. With regard to the question of passenger tickets and return tickets being available by two different lines serving the same place, you are aware that that is done in some cases?—I believe, as I said, it is done on the South Western line between Portsmouth and London. I am not aware of any other case.

11734. It is done by the London and Brighton Railway and by the South Eastern Railway between Redhill and London?—Yes.

11735. (*Mr. Briggs.*) The Lancashire and Yorkshire Railway and the London and North Western Railway Company do it between Leeds and Liverpool?—I cannot see why it should not be general. They have a clearing house.

11736. (*Dr. Le Neve Foster.*) With regard to the point we have to consider with respect to the coal supplies and coal resources and the most advantageous way of dealing with coal, I understand you to say that would reduce the expenditure of a railway company, and so indirectly help the mineral traffic?—That is the suggestion—that they might give the same facilities in the way of trains to the public; reduce the number of trains and thereby reduce their cost, and philanthropically devote the money saved to reducing the charges to mineral traffic.

11737. It would be a benefit to the railway company, a benefit to the passenger, and a benefit indirectly in cheapening the mineral traffic?—Quite so.

11738. With regard to these large wagons. I gather you are advocating the use of large wagons in mineral traffic, not necessarily for all goods traffic?—Oh no, I do not think they are suitable for all goods traffic.

11739. You agree with what has been said by various railway people that in a small country like England, it is not necessarily advisable to copy America, where the conditions are different?—Obviously when the average load of a goods wagon is only about 2 tons, a 10-ton wagon is plenty big enough to carry it.

11740. Did I understand you rightly to say that 30 per cent. to 40 per cent. of the cost of your pig-iron was railway rates?—That is so.

11741. Partly for ore and partly for coke?—Yes, and partly for limestone.

11742. (*Professor Dixon.*) I am afraid I have not quite followed where you get these figures from in paragraph 2 of your statement. Can you tell me how the figure of 2s. 5·74d. is obtained. Is that an official figure, or is it one you have calculated?—I get it in this way: the official figure, taking the trains all round, is 3s. per train mile.

11743. For every kind of train?—Yes.

11744. Inclusive of all costs?—Inclusive of all costs. Then there are certain charges which ought fairly to be attached to the goods and passenger traffic as distinguished from the mineral traffic. These amount to 6·47d.

11745. (*Chairman.*) The addition of those makes the 3s.?—Deducting the 6·47d. from the 3s. leaves the train mile at 2s. 5·74d. Then in order to get at the cost of the mineral train I deduct the 6·47d. from the 2s. 5·74d.

(*Professor Dixon.*) That is what I cannot understand.

(*Chairman.*) Well, it really is an estimate. He first persuades himself that 6·47d. is the amount which is incurred in cost.

Professor Dixon: For passenger and goods?

(*Chairman*): Apart from mineral.

11746. (*Professor Dixon*): Why do you take it away again to get at the mineral cost. That is what I do not yet understand?—You see the cost all round is 2s. 5·74d.

11747. No, the cost all round is 3s. The 2s. 5·74d. is after deducting certain charges: you say "making together 3s."?—Yes.

11748. That I take it is the average inclusive cost per train mile?—Yes.

11749. Then you say certain charges are made exclusively for passenger and goods, and that comes to 6d.?—Yes.

11750. So that the remaining amount is the average cost for mineral trains?—For all trains.

11751. For all trains. I do not see why you should then take away the 6d. again?—The average cost with all trains being 2s. 5·74d., and that which is exclusively passenger and goods being 6·47d., that must be added to the 2s. 5d. to get at what is the cost of the goods and passenger traffic.

11752. I am quite clear about that.—Then in order to get at the mineral traffic you must deduct it. The average being 2s. 5d., there is 6d. to be added to the passenger figure, and 6d. to be deducted from the goods.

(*Chairman.*) It is a little complicated, I think. But you have rather changed your view, Sir Alfred, because I understood you to say before, as apparently you repeat now, or did repeat a moment ago, that the cost was 3s. per train mile. You now say, and this is borne out by your figures, that the cost per train mile all round is 2s. 5·74d. Is that so? Professor Dixon says if the cost is 3s. and you deduct 6·47d. from 3s., which brings you down to your figure of 2s. 5·74d., why do you again deduct 6·47d. from 2s. 5·74d., bringing it down to 1s. 11d.? You now say, and I am not sure that that is not probably correct, that the cost all round per train mile of all trains is 2s. 5·74d. instead of 3s.

11753. (*Professor Dixon.*) They cannot both be true?—No. You take first of all the trains; then you deduct from that that which is exclusively goods and passenger. That gives you the cost all round of all the trains less what is exclusively goods and passenger traffic; then, in order to get at what is the goods and passenger, you must add the 6·47d.

(*Professor Dixon.*) That is perfectly clear; but why should you take the same figure away again to get at the mineral train cost? That is what I cannot understand. The figure you have added on is the cost of the passenger and goods traffic. You have already taken it off to get the 2s. 5d.

(*Chairman.*) You see, according to his own figures, if you deal with it on that basis it would work out in this way: he makes it 3s. per train mile after making that alteration of 6·47d., and if you add 3s. and 1s. 11d. together, then it gives him about the 2s. 5·74d. per train mile all round, assuming they were equal qualities.

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(*Witness.*) Yes, that is the explanation; that makes it clear—you get 4s. 11d., and then divide that by 2.

11754. (*Mr. Briggs.*) Surely the first statement must be incorrect, that the cost all round per train mile after deducting the charges which were exclusive of passenger and goods, is 2s. 5·74d. Is it not that the total cost all round is 2s. 5·74d. to start with?—No.

11755. I think it must be so?—No, the Chairman has explained it and put it very clearly; in order to get a total cost you must add the 3s. to the 1s. 11d., that is 4s. 11d., and then divide that by 2 and you get 2s. 5d. with a fraction.

11756. (*Chairman.*) That is the cost all round?—Yes, that is the cost all round, after deducting the special charges.

(*Chairman.*) That is, assuming that the minerals are equal?

11757. (*Professor Dixon.*) Yes, assuming they are equal?—Yes. Of course they are not equal, but it is putting it that they are equal.

11758. Is that the way in which the 1s. 11d. has been got—by assuming they are equal?—Yes, certainly—equal less the 6·47d.

11759. (*Chairman.*) You have not got the figures there from which you took these figures, have you?—Yes, I have.

11760. If you could give Professor Dixon the answer to the first question, then we shall have it clearly?—Shall I work this out without taking up your time now and send it to the Secretary.

11761. Yes, if you would do so; but let me see if I can make clear what appears to me to be the real point. The real point is, is the cost all round per train mile of all trains 2s. 5·74d. or is it 3s.?—I would rather send to you the statement, which I will make quite clear, if you will allow me; it will be better than taking up your time now.

11762. (*Professor Dixon.*) Thank you. It is not quite clear on the proof. There is one other question I should like to ask you, with regard to your statement as to the comparisons of the train loads of the four great English railways with those of the Baltimore and Ohio Railway. I suppose it is the fact that there is much less long distance traffic done on these English railways than on that American railway?—Undoubtedly.

11763. Next, I suppose there are very much smaller trains run in England for short distances?—I have no doubt that is so.

11764. If you compared the long distance traffic in England with the long distance traffic in America, I suppose this difference would not be so marked?—Well, we have no rate of anything like one-fifth of a penny per ton per mile.

11765. I am not talking about the rate, I am talking about the train load. You give as the average train load on the North Eastern Railway, 92½ tons?—Yes.

11766. I suppose one sees very much larger train loads than that commonly running on English railways?—Yes.

11767. I mean that would be quite a small train, would it not?—That is the average that they give.

11768. Yes, that is including some very short trains which only run short distances?—Oh, it is all round no doubt, including short and long.

11769. My point is this, that there is very much shorter traffic in England with small trains, which of course brings this average down, which is necessitated by the closeness of the boundaries of England?—I do not know that a short run is necessarily a small train. I should not think it is.

11770. Could you tell us whether there are larger and smaller charges in America for long and short distances, or are these rates that you give us, one-fifth of a penny, for all distances?—Those are the average rates.

11771. Then they are graded in America?—Oh no doubt.

11772. And graded also not only for the distance but for the amount carried?—I am not acquainted with the fact, but I should think so.

11773. Therefore it would be dearer to consign 10 tons in America than it is to consign these large trucks of 30 and 40 tons?—I really am not sufficiently acquainted with the American figures.

11774. You do not know about the smaller traffic in America?—No, I do not know.

11775. (*Sir George Armytage.*) I understand you to say that in your opinion a reduction of rate would be to the advantage of the collieries of the country?—Certainly.

11776. And you do not suggest for a moment as I understand, that this rate should come out of the pockets of the shareholders of the railway company?—No, I do not see why it should, I do not think it need.

11777. But that the railway companies should re-adjust their arrangements so as to be able to work cheaper?—Precisely.

11778. In other words, you are of opinion that they are not doing their work as economically as they might do?—That is my opinion.

11779. Your cure for that is that they should run fewer passenger trains, which, in your opinion, are not profitable?—That is so, or rather I ought to say not so profitable. I do not mean to say that they run them actually at a loss, though I have no doubt some passenger trains are run at a loss.

11780. And that they should use larger trucks and carry longer trains?—That is so.

11781. How would you persuade the various colliery proprietors, dock proprietors, and others, to provide facilities for these larger trucks?—Simply by giving them an advantage in the rate for doing so.

11782. A pecuniary advantage?—Precisely.

11783. That means to say you would carry their coal for a lower price and therefore you think that they would immediately alter their screens, alter their turntables and so forth?—Certainly.

11784. But are there not cases, and many cases, of collieries which these larger trucks cannot get to at all, in consequence of the sharpness of the curve?—The larger trucks can get round any curves that the small trucks can get round, and better, because they run on bogie wheels, and the bogie wheel base is shorter than the 10-ton wheel base.

11785. That is true to a certain extent, but are there not a great many coal lifts, sidings and arrangements of turntables which could not be used for the larger trucks?—The turntables would not be available for the longer trucks.

11786. Do I understand you to seriously mean that you think all coal trucks ought to be larger?—I would not say all trucks; I would not forbid the use of all small trucks. Where a man wants a small consignment let him have a small truck; but what I say is, where a man will give a large consignment in a large truck and there is an advantage to the railway company in his doing so, give him the inducement and give him the benefit, or, at any rate, some of the benefit.

11787. The figures which you have given us in paragraph 2 of your proof, I understand, you have taken from the London and North Western report?—Yes.

11788. Why do you take these from the North Western report. What was the particular object in doing that?—I thought it was a typical railway.

11789. Yes, but not an average one?—Well, it is a favourable specimen, certainly, from the railway point of view.

11790. Would it not have been better to have taken your figures from the Board of Trade Report, which gives you the average of all the railways?—But I would submit that as some railway companies, such as the southern lines, do not carry coal to any large extent, any average which would include them would give no useful information.

11791. You say that the last half-yearly return of the North Western shows that the receipts per passenger train mile were 4s. 8d.?—Yes.

11792. And for goods and minerals 7s. 9d.?—Yes.

11793. You have really taken that figure as a basis for the whole; but now, as a matter of fact, according to the Board of Trade returns, 4s. 3d. was the receipt per passenger train mile and 7s. for goods?—Yes.

11794. That would throw the calculation out a bit, would it not?

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Sir Alfred Hickman.

17 Mar. 1903

(*Chairman.*) Do you mean that is for the North Western.

11795. (*Sir George Armytage.*) Yes, you have given us the North Western figures, and all you have given us has been on the North Western figures. The Board of Trade figures for all railways are 4s. 2d. for passengers and 6s. 11d. for goods?—When we are discussing the question of coal rates I think any comparison with the South Western, the South Eastern, Great Eastern, and so on would be of no use.

11796. I do not think you can arrive at anything with any great degree of accuracy from the figures of one railway company, can you. Perhaps, for the sake of illustrating that, I might mention that the receipts per train mile as appearing here, on the North Western which you give, are 7s. 9d. for goods and minerals?—Yes.

11797. On the Lancashire and Yorkshire they are 10s. 8d.?—Yes.

11798. So that if you had taken, we will say, the Lancashire and Yorkshire figures or any other figures, it would have given us entirely different information to what you have given us to-day, would it not?—Of course that would strengthen my case very much if I had taken the Lancashire and Yorkshire, but I think it would have been open to the objection that I had chosen the Lancashire and Yorkshire, and that that was not typical.

11799. But what I suggested was why had you not given the Board of Trade figures?—Because I do not think the average of all the railways in the country is any fair indication of what the mineral traffic would be. The London and North Western Railway is a fairly all-round railway for passengers, minerals and goods

11800. (*Chairman.*) It is less in proportion, is it not, as regards minerals than the Midland, for example?—Probably it may be.

11801. (*Sir George Armytage.*) You mean it is nearer the average of the whole?—I should think the London and North Western is nearer the average.

11802. (*Chairman.*) It is not a specially favourable one?—No, I thought it was a fairly average railway on the whole to take.

11803. (*Sir George Armytage.*) In these figures you say that the cost all round per train mile on all trains, deducting the charges which were exclusively passenger or goods, was 2s. 5·74d., and the charges which were exclusively passenger or goods as distinguished from mineral, were 6·47d.?—Yes.

11804. What are those charges which are exclusively for passengers and goods; what items have you taken out of that London and North Western account?—I propose, if it meets with the approval of the Commission, to send these figures in detail exactly.

See Page 131.

11805. Showing exactly how they are arrived at?—Yes.

11806. For example, you say "the charges which were exclusively passenger or goods"; have you, for instance, taken out wages, "porters" wages?—No.

11807. (*Professor Dixon.*) May I suggest that after the words "the cost all round per train mile of all trains," the words "deducting the charges which were exclusively passenger or goods" should have been left out. Then your proof seems to run correctly; the average cost per train mile of all trains is half-a-crown; the cost for exclusively passenger and goods trains is 6d. more, making 3s.; therefore, the average cost of the other lot—we will take the trains as equal—is 6d. less, that is 2s.?—Yes, I think that may be the explanation.

See Q. 11858.

11808. (*Chairman.*) I venture to suggest to you that when you get your proof, following what Professor Dixon says, you might look at that point, and if so, you might correct the evidence?—I will do so.

11809. (*Sir George Armytage.*) At any rate you will in the statement you send us, exactly specify what these charges are which you say are exclusively for passengers or goods?—Yes, I will do that.

11810. (*Chairman.*) Perhaps, Sir Alfred, at the same time, inasmuch as you are going to take them from this report, you will specify the page on which the figures are found. Then we shall have it all together?—Certainly.

11811. (*Sir George Armytage.*) I think you explained to us that you did not take into account the return of the empty wagons?—That is so.

11812. It would be material?—Certainly.

11813. Did I understand you to say that you would be glad if there were no traders' wagons at all, and if they all belonged to the railway companies?—Yes, that is the ideal system, undoubtedly. It would be a benefit all round. In my own particular case I should have a few wagons necessarily for keeping stock and so on.

11814. Do you think that your Association would be in favour of any sort of scheme by which it could be arranged that traders should build no more wagons, and that railway companies should arrange to provide for the numbers that they might require at various collieries, and so forth, as occasion arose?—That is a point on which I have not consulted the Mining Association, but I have no hesitation in saying that in my opinion it would be beneficial to the trade generally.

11815. There is not so much profit made out of them as would make it worth their while to retain them?—No.

11816. Do you keep any separate account of your wagon stock?—Yes, certainly.

11817. I mean, you have a means of knowing?—Yes. There is no doubt the wagons could be worked more beneficially by the railway company.

11818. (*Chairman.*) But did you not tell us you had first of all sold your wagons to the Midland Railway Company and then subsequently, for some reason or another, you had to provide yourself with other stock?—I have been obliged to do so, because we could not always depend upon getting the supply.

11819. (*Sir George Armytage.*) Of course if such a thing as I have foreshadowed were done, you would be certain of a supply—it would have to be arranged?—Yes.

11820. Would that not be a means of providing, at the different collieries, the class of wagons which they would be most likely to require?—Yes, I think it would.

11821. Because some consignments are very large and constitute full train loads, and the others are very small?—Exactly.

11822. As you have told us, Lord Stalbridge said his average consignment is only 17½ tons?—Yes.

11823. You would hardly pull out your best engine and your biggest train for that, would you?—No.

11824. You say: "Let railway companies give special rates for full train loads and for 30-ton truck loads and they will soon find the traders will avail themselves of them." Do you not know of instances in which there are different rates quoted for large consignments and for small ones?—The only instances I know of are not in mineral traffic, but in iron and steel traffic.

11825. Do you know of any in any coal traffic at all?—I do not.

11826. Then how does this case which you gave us arise, of this lower rate of ·58d. per ton per mile on 111 miles when you are paying ·82d. per ton upon the average?—That is not for large consignments; it is for any ordinary consignments.

11827. But you gave us a case just now which you had made an arrangement to pay ·58d. per ton per mile for I think you said 2-ton loads, did you not?—Oh no.

(*Chairman.*) It was a long distance of 111 miles.

11828. (*Sir George Armytage.*) Yes.—I am afraid I did not make myself distinctly understood. For those train loads which I mentioned I did not give any rate at all.

11829. Then what was the ·58d. per ton per mile?—It is the rate from my colliery to Bath.

11830. That is not an excessive rate, is it?—No, it is a low rate.

11831. (*Chairman.*) Perhaps you may know, is that a case where the rate from your particular colliery, or the distance from your particular colliery, is governed by a shorter route?—I should think it is very likely.

11832. Because my recollection is that this particular rate was a lower rate per ton for a longer distance than the London rate you quoted us?—Yes.

11833. Probably, therefore, although it is 111 miles from your colliery to Bath, that rate may be governed by some route which is shorter than 111 miles?—Yes, I have no doubt it is influenced by that.

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11834. (*Sir George Armytage.*) Then you told us of a case of starting entirely new traffic and that you offered to provide some new large wagons for the traffic if the company would allow you something They refused to allow it, and you say it is now carried in the old wagons?—Yes.

11835. Did you suggest to the company that they also might provide wagons for that traffic?—They would not entertain the idea for a moment.

11836. They told you to find your own?—Yes.

11837. In your opinion they are carrying a great deal of unnecessary weight. Is that so?—Certainly.

11838. You refer to the 1892 Act, which was supposed to have settled everything. Is it not rather premature to suggest any alteration of that Act in so short a time?—You may think so, but I think there are plenty of improvements that could be made in it.

11839. You give us the average train loads on four English railways, from the North Eastern manager's statement, and you compare it with these American lines. It seems to be rather an old question, but do you not think it has been sufficiently threshed out, and that the public generally are acquainted with the fact, that the distances are so very different and the whole circumstances are so very different, that it is hopeless to suppose that English railway companies can carry traffic the distances that they have to carry it at the same rates?—I think there is no possible question that the train loads on English railways could be very largely increased with a very much diminished cost. I do not mean to say that the average could ever be brought up to 1,800 tons or 1,000 tons per train load, but that it could be increased beyond the present miserable quantity that is carried, I think there can be no possible question.

11840. You are probably not aware that the Lancashire and Yorkshire Railway are running train loads of 1,000 tons per day?—Well, it only strengthens my argument if the Lancashire and Yorkshire Railway Company can do it.

11841. But under only certain circumstances where there are thoroughly full train loads?—Yes.

11842. 600 tons of coal and 400 tons weight in trucks?—Yes.

11843. (*Chairman.*) I do not wish to intervene unnecessarily, but it would be very interesting to the Commission if you would indicate in what way you think on the English railways the loads could be largely increased, as you put it. I mean, what does it pre-suppose: does it pre-suppose co-operation, or whatever you may call it amongst the railway companies as regards goods and minerals in the way that you indicated would be your view as regards passengers? Let me put it in this way, if I may, just as an illustration: take one of your collieries: probably you have three railway companies running into them, possibly four?—We have three.

11844. Could you give each of those three railway companies a full load every day?—No.

11845. Therefore it pre-supposes, does it not, some arrangement by which the wagon stock, if you like, shall be available as a whole. and that the engines shall be available for taking a full load on behalf of all the companies. In what other way would it be possible to provide these full loads?—I think if either of the railway companies, or if all the railway companies, said "We will take a train load at so much per ton per mile from one station to another," we could often arrange (I do not say every day, or to every place) for train loads very much larger than the present train loads.

11846. But would it not involve, as I put it, in the case of your own colliery, if you were going to do that, that really instead of having three small loads, if you like, taken away by three separate companies, you would have to have the whole of your produce taken away by one?—I do not think that would work, because we only send——

11847. No, I do not think it would either, but I want you to explain that to us?—No, I do not think that would work, because we do not have to send to three railways, except when we send to the different stations on the different railways.

11848. To different destinations and with trucks labelled for different destinations?—For instance. if the London and North Western said to us "We will take on a 200 tons load 20 per cent. less than we are charging for ordinary traffic——

11849. 200 tons is no good?—It is double the present quantity.

11850. No, it is not double the present quantity that is actually taken, nor is it half the present quantity, nor, as we hear from Sir George Armytage, is it one quarter of the present maximum. It is double the average quantity?—Well, we will say 400 tons—and 400 tons is a much larger quantity than the average from my colliery.

11851. You mean the gradients would not permit it?—They do not do it, at any rate; I do not know why they do not do it.

11852. (*Sir George Armytage.*) Do you not think it is obvious that if any of these three competitive companies which come into your district thought it would be more profitable to work with these larger trucks and these larger engines, they would naturally do it, even for the purpose of getting the traffic away from their competitors?—I am surprised they do not do it, I must confess.

11853. From what you say, they all seem to be of the same mind?—I am surprised they do not do it. I think attention is being directed to it.

11854. Does it not really come to this, that there is room for large trucks and there is room for small trucks?—Certainly.

11855. And that the view which you, as I understand, take, that all these mineral trucks, should be large trucks, will not hold water?—I never said that they should all be large trucks.

11856. But I understood that?—I certainly said, and maintain, that if advantages were given for large trucks, a very large number of large trucks would be used at a great reduction of cost. But after all, there is room for some small trucks, undoubtedly.

11857. Then there is another difficulty which I see, and that is this. You are probably aware that some of these large trucks are fitted with automatic brakes; they have great weight and they require a good deal of power to arrest their progress?—I have not seen any with automatic brakes.

11858. (*Professor Dixon.*) I am sorry to trouble you further upon this matter, but there is one other point. In paragraph 2 of your proof you state "and deducting the charges exclusively passenger and goods from the mineral train cost"; ought not that to read "from the average train cost"?—It should be "to arrive at the mineral train cost" instead of "from the mineral train cost."

11859. The words "mineral train" should be "average"?—Yes.

11860. I have written out this statement in a slightly different form. Will you allow me to read it to you in order to see whether you agree?—If you please.

11861. I should read it in this way: I want to be quite clear that I understand it. "The cost all round per train mile of *all* trains was 2s. 5·7d." I think we are all agreed upon that now—that is without any deduction. Then "The special increased charge for goods and passengers per train mile was 6·4d."—meaning by "increased charge" the charge above the average.

11862. "Therefore the cost per train mile of goods and passenger trains was the average cost, plus this special charge (adding the two together) say 3s." I think we are all agreed on that point, are we not?—Yes, I think so.

11863. Then the next line: "And therefore the cost per train mile of mineral trains was the average cost minus 6·4d., equalling 1s. 11d.?"—Yes; I believe that is a correct statement of what I ought to have said.

11864. Then perhaps I may take this as being what we all understand?—Yes, if you please.

11865. Just one word upon that. Your argument appears to me to assume that the number of train miles run by mineral trains is the same as the number of train miles run by goods and passenger trains combined?—It is not as a matter of fact.

11866. But your argument seems to assume it?—For the purpose of that calculation that is assumed.

11867. (*Mr. Maclay*). You have not said it in so many words, but I gather the whole point of your evidence is this, that the railway companies charge against the mineral traffic a much greater proportion of the cost of working the railways than they should do?—Yes.

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Sir Alfred Hickman.

17 Mar. 1903.

11868. And you would suggest, perhaps, that that is not a matter which need affect dividends, but rather that an addition, if required, should be made to passenger fares and a reduction made in the case of mineral traffic?—I think that is a fair inference. I have not put it quite so distinctly as that.

11869. But that is what you point to, I think?—That is really what it comes to, that the passengers are favoured by the railway companies; the passenger traffic is undoubtedly favoured.

11870. Then you spoke about limestone?—Yes.

11871. Does that limestone come to you in wagons, which are provided by yourselves?—No, they are provided by the limestone company.

11872. Not by the railway company?—No.

11873. Do you know the system of charge on the North Eastern Railway Company; is it so much per mile?—No, I think they charge on the same system as other companies; they charge rates between certain stations; they do not profess to charge so much per mile.

11874. Do you know what the system of charge is for the use of the wagons?—I do not know. I am not a trader on the North Eastern at all.

11875. The reason I put the question is that some railway companies object to supply wagons, because they assert that the consignees hold back the wagons too long, and they are not able to recover detention money?—Yes; I believe on the North Eastern the rate includes wagons and they supply all the wagons for their mineral traffic.

11876. (*Chairman.*) I should like to ask you one question, in order to clear up a point I am not quite certain about. In speaking of the advantages which, in your opinion, would accrue from the use of the larger wagons by reason of the less dead weight and the desirability, as you put it, of encouraging the traders to use the larger wagons, you made some suggestion as to the kind of allowance that should be made by the railway companies in order to encourage or to stimulate the traders to use these larger wagons?—Yes.

11877. Did I gather correctly that this was your view; that the railway company should offer for train loads and larger wagons to give to the trader what represented half the dead-weight saved?—I think they should go further than that, certainly.

11878. I think you will find that that is what was said in your evidence?—No, what I said was this, that in the particular case I referred to I offered to provide wagons if half the dead-weight saved were allowed: but in my general evidence as to what ought to happen throughout the country I think that a much larger allowance than half the saving of the tare should be allowed: I think something like a fair proportion of the saving in the tare and the saving also in the conveyance should be allowed.

11879. Yes, but you assume the saving in the conveyance. You say that that distinguished authority, Sir Henry Oakley—I am not sure that he will support you if he comes—found that a 20-ton bogie wagon took no more power to pull it than a 10-ton wagon. I think lately there has been a change of opinion about the loss of friction by bogie wagons. I do not think with regard to these big bogie passenger trains that are being hauled about the country that the locomotive engineers and superintendents take very kindly to them in talking to their directors, as to their costing no more power to pull them. I only want to get it clear, because I think you will find in your evidence that that has been the impression which was gathered. Therefore, if that is not your view I should like to draw your attention to it?—Most certainly I think much more than half the saving of the tare should be allowed.

11880. You would not limit the benevolence of a railway company to that?—Most certainly not, I think that would be very inadequate.

11881. To encourage or stimulate them?—Yes.

11882. By the way, would that go to the customer, or would it go into the pocket of the coal merchant?—I do not know. It would go in the reduction of the cost of coal.

11883. It would find its way somewhere. Now we have had some very interesting evidence upon two points one is the great saving which is possible in the manufacture of iron by use of modern processes, and the other the great saving in coal which can be effected by the use of certain machinery and processes for turning it into gas and then into heat or power. Staffordshire is one of the districts where the Mond gas is being put into operation, is it not?—It is not yet in operation.

11884. You mean it is not yet in operation as regards the public companies supplying it?—Exactly.

11885. But it is in operation, I understand, in the Midlands as regards Mond plant, or a plant for the production of the producer gas has been supplied to particular factories?—I believe it is to a small extent.

11886. Do you yourself look forward to power being conveyed in future by means of gas pipes; because if so, that will modify the view with regard to large wagons?—I do not think that it will ever make much difference in the coal traffic.

11887. Why?—Because the coal will have to be carried to some central station after all.

11888. A central station in the sense that if you have half a dozen collieries within half a dozen miles, you will have some plant in the middle of them: do you mean in that sense?—No, the plant would be placed somewhere in the middle of where the gas would be likely to be used.

11889. But that is not the view which has been presented to us; the view which has been presented to us is that the coal should be converted into gas practically in the neighbourhood of the colliery and brought to London by means of pipes?—That is a scheme I had not heard of.

11890. But is that not the scheme of the Mond Gas Company?—So far as I am acquainted with it, a gas producing manufactory is being erected in a central position in what they call the Black Country, that is practically between Birmingham and Wolverhampton, and it is proposed to distribute the gas throughout the district for manufacturing purposes.

11891. Would the manufactory of the gas be far away from the coal pits?—Not very far, but I do not think it would be a less distance than the average that the coal has to be at present carried to the different manufactories. The manufactories are clustered in the district, and this is a central place in the district for the production of the gas, and the coal will have to be carried to that central place about the same distance that it is at present being carried to the different manufactories to which the gas will be conveyed. I do not know whether I make myself clear.

11892. Yes, I think I understand you, but I am surprised to hear what you say. I will put this proposition: coal is to be carried ten miles to the place where the gas is to be made, and the distance the coal is to be carried to that point is to be as great from the colliery as it is from the colliery to the factory?—Yes.

11893. But is still to be carried from the place where the gas is manufactured to the factory, which you say would be a distance equally great?—The gas manufactory is in the centre of the district and of the manufactories using the gas, which surround it at distances from nothing or a few hundred yards up to about six miles. At present the coals are conveyed to these manufactories all the way round.

11894. A distance of six miles?—A distance of six miles, on an average.

11895. And it would be still a distance of six miles from the place where the gas is to be made?—Precisely; they are varying distances, but, on the whole, I do not think much would be saved in that way; there might be a little, possibly. There would be this advantage, that supposing the scheme were carried out on such a scale as to supersede the use of coal at all at the works which is not very likely, there would be an advantage of a larger quantity going all to one spot instead of being distributed to various places.

11896. And the large wagons then would be more practicable?—Yes.

11897. And larger train loads?—Yes.

11898. Has this plan been applied to any of the large trade manufacturing concerns in your district?—Not yet. It is being applied, I am myself using gas from blast furnaces for driving engines; I am putting up 4,000 horse power to use the gas for driving engines instead of boilers and steam engines.

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11899. (*Sir George Armytage*) : For what purpose is that?—In the first place for blowing furnaces—blast engines ; and, in the next place, for driving dynamos or electric motors to drive different machines. We have 50 or 60 little engines of various sizes about the works, for various purposes, and we propose to supersede these entirely by electric motors.

11900. (*Chairman.*) And this it is proposed should be done, I understand, by engines using what are at present waste gases?—They are more or less waste. We use them at present under the boilers.

11901. But you propose to use them in the engines direct?—Yes, exactly, and it is supposed that they would then go about four or five times as far.

11902. (*Sir George Armytage.*) It means that you are going to rip out your engines and put in gas engines? —Yes.

11903. (*Dr. Le Neve Foster.*) And electric motors?— We put electric motors in place of the steam engines.

11904. (*Professor Dixon.*) What is the largest power? We are putting duplicates of 600 horse power.

11905. What is the type of engine you are putting up? —We have the Premier, the Crossley, and the Seraing built by Richardson Westgarth and Co., of Middlesbro'. *Sir Alfred Hickman.* 17 Mar. 1903.

11906. You are using three different types. Have you put in the Körting engine?—No.

11907. (*Chairman.*) Would you, from your knowledge, agree with the view which has been put forward, that the German iron and steel manufacturer is far ahead of us in the economies he effects in this way?—I have no doubt they are very forward, indeed, and that in many respects they are ahead of us.

11908. And that adopting these methods would effect in itself a very large saving in the consumption of coal? —Unquestionably.

11909. And, therefore, that that would add to the resources of the country?—Certainly. There is great room for improvement in ironworks and manufactories in regard to the consumption of coal, of that there is no doubt.

11910. Railway companies are not the only laggards? —By no means.

ADDITIONAL particulars furnished by Sir *A Hickman* at the request of the *Chairman.* (Question 11804).

	£ s. d.	£ s. d.
The following items in the London and North Western Account for the half-year ending 31st December 1902 belong exclusively to Passenger Traffic :—		
Compensation for accidents, passengers (page 7)	6,598 - 7	
Government duty (page 7)	29,882 13	
Rebuilding stations (page 8)	25,000 - -	
Repairs and renewals of carriages (page 8)	240,960 17 3	
		302,441 10 10
The following belong to passenger and goods traffic (excluding minerals) :—		
Repairs of stations and buildings (page 8)	65,568 11 3	
Mileage of carriages and wagons of other companies (page 7).	18,076 9 2	
Clothing (page 8)	18,683 - 2	
Horses, harness, vans, provender, &c. (page 8)	164,057 4 10	
Agents commission (page 8)	211 8 8	
Hoists, hydraulic cranes, &c. (page 8)	36,617 - 8	
		303,213 14 9
The following belong exclusively to goods :—		
Repairs and renewals of wagons (page 8)	107,945 - 8	
Wagon covers, ropes, &c. (page 8)	20,807 1 2	
Compensation for accidents and losses, goods (page 7)	51,208 18 8	
		179,961 - 6
TOTAL - - - - £.		785,616 6 1

These figures do not include porters, ticket collectors, &c., &c., nor any estimate of the extra cost in fuel and wear and tear of fast as compared with slow trains, so that it is abundantly evident that the passenger and goods train mile costs much more than the mineral, but it is not possible from the materials furnished by the Company to give any accurate account of what the difference per train mile amounts to because the mileage of goods and minerals is stated together.

Mr. JOSEPH SHAW, called ; and Examined.

11911. (*Chairman.*) You are chairman of the Powell Duffryn Steam Coal Company?—Yes. *Mr. Joseph Shaw.* 17 Mar. 1903.

11912. A member of the Monmouthshire and South Wales Coal Owners' Association, and a member of the Mining Association of Great Britain?—That is so.

11913. Are there any circumstances which apply particularly to the coal-field of South Wales as compared with other districts, in your opinion?—I was engaged all through the Enquiry in regard to railway rates, and I remember we had four years of it, but I hope you are not going to start on the same matter again. Every district throughout the Kingdom has different circumstances. South Wales is most like Newcastle, I should say ; its trade is almost entirely shipping The collieries, as you know, lie to the north of the Severn Channel, and the coal drops down to the ports of Barry, Cardiff and Newport, where the larger amount is shipped.

11914. Does that mean that the grade is mainly with the load?—The grade on the Taff Vale Railway is altogether with the load, but in regard to some of the collieries on the Great Western Railway, they have a little bank to run up-hill, and then they get it down-hill. The Taff Vale Railway, train load is about 600 tons. I have a note with regard to that, and I will deal with it presently.

11915. (*Professor Dixon.*) Do you mean that is the average train load?—I would not say the average, but that is what they consider a full train load.

11916. (*Chairman.*) You have already told us that the South Wales coal trade is very largely an export trade for shipment?—Very largely ; in fact, I should think the whole output of South Wales is something like 40,000,000 tons, and I should think, roughly, at the present moment about 30,000,000 goes for export ; that is, of course, not only for export to foreign ports, but a certain amount of it goes to places like Southampton, Birkenhead, London, and so on, for steamship bunkers.

11917. It almost follows, does it not, that traffic of that kind would come in great lumps?—It does. Our average consignment would be very much larger than what you were talking about on the North Western Railway just now.

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Mr. Joseph Shaw.

17 Mar. 1903.

11918. Do the traders in the South Wales district own their own wagons to any extent?—Yes, entirely, and we lay a great deal of stress upon this, because we think any disturbance in this direction would be to the detriment of the trade. I can give you two or three reasons for it: at the present moment we ourselves—that is the Powell Duffryn Company—have about 5,000 wagons; that represents a week's output. There are very few railway companies in the kingdom that would care to keep for all their collieries a week's output. It is absolutely essential, in South Wales, that we should keep our collieries working from day to day: a stoppage with us is a very costly thing. Besides that, we have big ships coming in, and we have large quantities to put on board those ships, which are up to 12,000 tons carrying capacity; so that we must very often hold back in our sidings a very large quantity of coal. Therefore it is essential for our trade for that reason alone, to keep our own wagons. Then there is another point. I have known instances when we were coaling the transports at Southampton to go out to the war, when we could not get a boat to take the coal round to Southampton quick enough, and we had to telegraph up to the collieries from Cardiff at about 6 o'clock in the evening to alter the arrangements with regard to all the wagons which were standing there, ready to go to Cardiff during the night, and to send them all down to Southampton; we had special arrangements with the railway company so that they ran specially on to Southampton that night, and they were delivered alongside in Southampton the next morning. That is how we were able to keep the transports going. That necessitates our owning our own wagons; we have so many railway companies to deal with. As you know, there is a difficulty in dealing with the wagons when you have foreign wagons coming in over all the lines; it would practically make our trade, not impossible to carry on, but very difficult to handle.

1919. Then I gather really from your own experiences that you think the working is better if the wagons are controlled by one authority?—Yes, by one authority, in this case the Colliery Company, because there are difficulties; we have foreign wagons coming into our sidings, and, as you see, we have very large sidings in South Wales. We have, for instance, foreign wagons in the shape of railway companies' wagons: there are always questions of demurrage, and who is to blame for it. For instance, North Western wagons will come in perhaps over the Taff Vale Railway and so into our sidings: if we keep them any length of time of course there comes an application, and then we say it is the Taff Vale Railway Company, and the Taff Vale Railway Company say it is us, and the usual bickerings go on. One authority controlling the wagons, as you say, my Lord, is much easier; in this case we say the one authority ought to be the trader.

11920. (*Sir George Armytage.*) On the other hand, these wagons block the line, and have to be carried back empty to you?—They must be carried empty: but with regard to that you know the Midland Railway Company tried the experiment of buying the wagons: well, you can ask the Midland Railway people about that: I do not know whether they are altogether contented with the arrangement: you see their wagons coming back empty. We do not use our coal wagons for anything except to bring pit-wood, and I do not think you can use them for anything else. We have large brick works, and we use special wagons for all those things. I am speaking as a practical man with regard to this: if we could use our wagons for bringing stuff back from Cardiff we would use them, but we can only use them for pit-wood.

11921. (*Chairman*). Having this large quantity of wagons really enables you to keep a number of them under load every day?—We can keep a certain amount under load, and it enables us to give quick dispatch at the ports. In one case in which we loaded at Newport, the Newport Docks wanted us to give them a record—we have done the same thing since at Cardiff—and we loaded 10,000 tons which we put into one ship, in, I think, rather less than 36 hours. That requires, before the ship comes in under the tip, that we must have a certain amount of coal standing there: we had in that case 3,000 tons of coal standing at the back of the tip so that she could immediately go on, and then we were only delayed in loading that ship by the trimmers.

11922. (*Sir George Armytage.*) Is not that a very usual thing?—We have a large quantity of coal when a big ship is coming in very often standing waiting for that ship.

11923. But it is a very usual thing for your progress to be arrested by the trimmers?—Yes. Of course they are building modern ships better now, and they are building them as what they call self-trimming ships, and we are able to ship the coal faster. Some of the tips at Barry are able to do about 600 tons or more per hour; they could do so but in practice they do not do more than about 300.

11924. (*Chairman.*) Apparently these figures indicate that your wagons are only filled once a week?—I can give you the exact time it takes our wagons, because we keep a wagon-book, and we have an inspector who goes about and looks after the wagons. We find they are sometimes stuck up in London, for instance, holding coal for some merchant, and we have to watch them. I can give you the average time they take to go to each of the ports and places where we send wagons These are the particulars with regard to the various docks at Cardiff—it is very curious how they vary; the East Dock at Cardiff takes 4·4 days; that is the average time occupied from the time the wagon leaves our siding till it returns.

11925. (*Sir George Armytage.*) How many miles is that?—About 21½ miles: The average run on the Taff Vale Railway is only 16 miles. Then to the Roath Dock, which has a better siding accomodation, and where perhaps we do not get hampered so much, 3·9 days is the average. It is the same distance practically: it is the group of docks at Cardiff that I am dealing with now. The East Branch West Dock, in Cardiff, 4·1 days. Cardiff itself (this is the town of Cardiff, where we only send small consignments), 7·7 days—that is where the merchant comes in. Barry, which is a modern dock, and has much better appliances than some of the old parts of Cardiff Docks, 3·5 days.

11926. (*Chairman.*) That is the best example you have given us?—That is the best example. Then Penarth, 3·7 days; Newport, 4·7; Southampton—of course, when we send by rail—10·1 days; we do not get a wagon back for ten days in that case, which is partly owing to Southampton not being very well equipped in the way of sidings, or anything, and there is a great deal of delay there. Southampton is entered, as you know, by only two pairs of rails over a public road. Then London stations, 12·7 days; those would be consignments to Rickett Smith, Cory's, and people like that. Then Cwmbran (this is to some steel works of Guest, Keen and Co's), 8·75 days. Cyfarthfa 7·8 days and single wagons 12·1 days.

11927. Would London stations in that case include these south of the Thames?—I fancy some of it goes to the south. Most of our traffic to London stations is, I think, not in our wagons, because Charrington, Sells and Company, and others, send their own wagons down.

11928. (*Sir George Armytage.*) The proportion is small compared to what you are doing at Cardiff?—Yes, small compared with that. I think we do the largest inland trade of any Colliery Company in South Wales: we do about a quarter of a million tons a year inland, I think mostly to London: whereas we do in Cardiff about 600,000 and 300,000 at Newport.

11929. (*Chairman.*) You are strongly of opinion that in South Wales traders should own their own wagons?—Very strongly, and it is the opinion of nearly all my colleagues in that district.

11930. Do you think it is necessary for the wagons to be interchangeable?—For our own traffic they must be. The instance I just gave you was this: we may at any moment have to alter the destination of a wagon either to the port for shipment to be used at the tips, and lifted by hydraulic machinery, or to London: if we do not get a ship coming in, by reason of storms, or something like that, we must send the coal up to London to keep our colliery going, or send it to Southampton or to Birkenhead. There must be wagons off which we can take the label and use them for any part of our trade.

11931. Is all your coal filled into the wagons direct?—At the screens—Yes.

11932. You do not stack it?—No, you cannot stack South Wales coal; first of all it would be too costly, and secondly the coal would deteriorate.

11933. (*Professor Hull.*) Does it not come out in very roundish blocks which would be unsuitable for stacking, in contradistinction to square suitable blocks?—It does not break in the same way as you see in the Midland coal; it has a much rounder form, and is very crumbly, and it makes very fine dust, as I daresay you

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are aware, Professor. It deteriorates very rapidly. Of course, in foreign climates where we have agencies, and where we have stacked it, we have found it deteriorates very rapidly when stacked. Besides, the cost of labour in stacking it is very serious.

11934. (*Chairman.*) You have had some experience with regard to matters connected with transport, and especially of coal, and endeavours to reduce the cost. Would you give us the result of your experience?—We have been trying for a long time to do everything we could in reducing the quantity of sidings. I may say that we cannot get very much reduction in the rates in South Wales.

11935. How do the rates in South Wales compare with other districts? Do you think they are high?—I think the rates in South Wales are very fair and very favourable to the trader. I think I could give you an example of that, in quoting some existing rates which I have a note of here. First of all, the rates in South Wales are practically governed by the Taff Vale Railway rate from any particular colliery to a particular point in the Bute Docks, to which all those rates are calculated. The mileage rate to that particular point on the Taff Vale Railway is ·575d. The old Taff Vale rate before the introduction of the Barry scheme, was ·875d., that was their maximum power. Then the traders were agitating at that time for further accommodation as well as to get a reduction in the rates, and the rates came down a little before the passing of the Barry Act (I remember the evidence that was given) to ·74d., and on the opening of the Barry Dock the Barry Company immediately quoted a low rate of about ½d., and down came the Taff Vale Railway Company with their ·575d. rate. They quoted at the same time a full train load rate, ·55d. which has been given up. Those distances are taken to a special point in the Bute Docks, which is short of where the traffic actually goes, so that the actual mileage rate works out to some of these docks, like Penarth, at a very low rate. I can give you the gross rate from Abercwmboi Junction to Penarth, 22¼ miles: the total charge, excluding the 2½d. for tipping and weighing, is 1s. $0\frac{6}{32}$d. That works out at ·542d. per mile. The same gross rate must be charged to the Barry Dock, because these docks are in competition, the Barry Company must, in order to get any traffic, see that the same gross rate is charged, therefore 1s. $0\frac{6}{32}$d. (or, in the Barry case, $\frac{7}{32}$) comes to ·499d.

11936. It is governed by the short route?—It is governed by the Taff Vale rate to this particular point. Then from the same point down to the Alexandra Docks at Newport, it works out at ·479d.

11937. For that short distance you do not think that is an excessive rate?—I do not think anybody grumbles about the rates in South Wales; so far as these are concerned I do not hear any complaint. Besides, we never can get that very much raised upon us, because the Barry maximum powers are only ½d. This is only shipment of coal I am dealing with. For coal coming in for local requirements, such as that sent to Penarth Town, the Taff Vale Railway Company charge a higher rate; I think they charge ·875d.; but that is only for a very small quantity, and it is only done in single truck lots. Then I have here the rates which the Great Western Railway charge to Birkenhead, Brentford and Paddington, and they work out at very low rates also. This is governed by the competition by sea, I see the Birkenhead rate works out at ·398d. per mile.

11938. Have you the distance?—160¾ miles. 5s. 4d is the total rate. Then the Brentford rate is for 169½ miles, 6s. 2d. for inland consumption; that works out at ·437d.; it is 5s. 5d, for shipment for bunkers, which works out at ·384d. So that we cannot expect to get very much relief with regard to these rates.

11939. (*Sir George Armytage.*) Are there any allowances for full train loads?—There are no allowances for full train loads there. Of course they would expect to get a full train load for that, I should think. There is nothing about allowances in the rate. As a matter of fact we have sent small quantities of coal to be tried at some of the electric works down by the river here; I have sent, perhaps, only as much as four or five trucks at these rates. In that Brentford rate I see there is some charge for tipping; they do the tipping in that as well; so that that brings it down even lower. I remember Sir George Findlay (I think he is the only railway manager I ever heard give evidence as to the cost of working coal trains,—I think he gave evidence before the Railway Rates Enquiry) said that the cost was about ¼d. per ton all round on the North Western. So that you see this is running it very fine, even here. Therefore I think, so far as the rates are concerned in South Wales, owing to competition by sea and by the Barry Company, we have got them down to a point than which we do not expect to get them much lower.

11940. In the case of the railway company finding the wagons, the charge is included in the rates, is it?—It depends. I think in the North Eastern case there was an agreement made at the time of the Railway Rates Enquiry, that the old Act should be kept in force, which put the obligation upon the North Eastern Railway Company in certain cases to find the wagons: and the charge there is inclusive. But in the case of the Midland Railway Company there is a separate charge. I have here all the statutory maximum rates upon every railway in England, but I think you will find in the case of the Midland, that where they find the trucks, they make a separate charge for the truck, and they obtained higher powers for charging on the Midland for their trucks than any of the railway companies did; they obtained higher powers than the North Western or the Taff Vale Railway, because the case for the Midland before the Railway Rates Commission was that they bought their trucks on certain terms, and therefore they ought not to be disturbed, one of the terms being that they should be entitled to charge, I think, 6d. per ton. In the other case, I think on the Taff Vale Railway, for instance, it is only 4½d. for a certain distance if they find the wagons.

11941. (*Mr. Briggs.*) The 6d. is a maximum?—Yes.

11942. (*Chairman.*) Then, of course, if the Colliery owner or merchant finds single wagons, that reduction is made?—Not that reduction, but a reasonable reduction is made, I think, according to the circumstances.

11943. Do you think that any improvement might be made in regard to the better utilisation of siding accommodation?—I think we have been tending towards that all along: I mean I do not think we have been standing still in any way, because little by little the size of the wagons has been increasing. You see years ago they were 2-ton wagons and I believe in some places now, as I shall mention afterwards, they still have those old 3-ton wagons. But we have been progressing from 3 tons to 7 tons and to 10 tons, and now we are gradually approaching the time when we shall increase those to, say, 12 tons, and the matter is being very carefully considered by the railways in South Wales. Mr. Beasley wrote to me only a few days ago saying he has a specification of a slight alteration to our existing wagons which can be done at a very small cost, so that the weight carried in our existing wagons will be increased 20 per cent., that is, to 12 tons.

11944. Does that mean raising the height of the wagon?—Some of our new wagons will actually now carry 12 tons without raising them at all; some of the old 10-tonners would require to be raised slightly. But we have plenty of new specification wagons now which can carry 12 tons, and we consider that the axles and the journals are quite strong enough for 12 tons.

11945. (*Sir George Armytage.*) Would they comply with the specification, then?—No, not quite; they want a little bit more on the journal. I have one of the specifications here.

11946. I mean do they carry out the Clearing House specification?—This one carries out the Clearing House specification, but the Clearing House have not a specification of a 12-ton wagon yet.

11947. (*Chairman.*) But have they not approved of one of 20 tons?—I have a copy of the specification of the North Eastern 20-ton wagon here, which Mr. Watson sent me the other day.

11948. (*Sir George Armytage.*) I am not at all sure that there is not some element of weakness about them?—The matter is being considered very carefully by the Clearing House.

11949. I know that many people say they can make their 10-ton wagon into a 12-ton wagon by raising it, or doing something to it; but then the question is whether the weight they will bring on to it will not upset it?—Yes, that is the case, but our 10-ton wagons or the modern specification wagons, are so strong and so well-built that they actually can and do sometimes now carry 12 tons. But the railway companies object. We have plenty of margin in hand. We see all the railway companies using these little by little. We are

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Mr. Joseph Shaw.

17 Mar. 1903.

able to alter those 10-ton wagons by putting in stronger wheels, axles, and so on, so as to be able to increase their carrying capacity. That is a very important saving to the traders, especially in my district, and it must apply all round, particularly in Wales, where it is very hard to get siding accommodation: we are in narrow valleys, and we find it very expensive sometimes, and very hard to get room to put our sidings, especially as we have coke, small coal, large coal, washed coal, and all that, and each different traffic requires a different siding. But by utilising the same area by putting 12 tons on it——

11950. (*Chairman.*) By putting a larger quantity on a square yard?—Yes, we get the benefit of it there, and the same with the railway companies; they get the benefit. The tare of the wagon, so far as I can see, will not be increased, or practically not; the journal has only to be slightly strengthened and that will not make the difference of a cwt., and you have less tare to carry back empty.

11951. Does the raising of the height of the wagon involve destroying the complete opening which is required at the side?—Our wagons in South Wales open at the end; they are all tip wagons. We have side doors also in case of inland traffic, but I do not think it would make any difference to those.

11952. You think they could still wheel in and out of them?—I do not think there would be any difficulty about that. Of course there is a point which has been raised with regard to this, about having to raise the screens owing to the wagons being higher. That is a point which will have to be very carefully considered by the railway companies who are running into the collieries at the present moment, because you cannot suddenly alter a man's screens. Take the North Eastern, for instance, where, if you send a 20-ton wagon up to a man who has not got arrangements to receive 20-ton wagons, you will block his siding with 20-ton empties and stop his colliery. The thing will have to be done very slowly, and as the circumstances will allow it to be done.

11953. Do you know anything about the method of altering weigh bridges which Sir Alfred Hickman has referred to?—No, but I think it can be done at a very small cost. We have had these 30-ton wagons on our siding. Many years ago the Leeds Forge people came to me over and over again about this, and we have very carefully considered these 40-ton wagons. First of all the initial expense is very great; they are very much more costly than the same capacity in 10-ton wagons; I think they asked something like £340 or £320 for a 30-ton wagon. A 30-ton wagon is rather absurd, because you do not get sufficient saving in dead weight. I think a 40-ton wagon is better, but there, I think, it would have been more expensive still. The last price we have paid for steel frame 10-ton wagons was, I think, about £65 or £66. You see there is a bigger capital expenditure required, and I do not think there is so much gain in the dead weight, especially if you could utilise the 10-ton wagons by building them up so that they get eventually to the 20-ton wagons. In that case, I think, you will get more saving out of them than with the 40-ton wagon. The 40-ton wagons have been tried; I think the Midland Railway Company have been trying some, and from what I hear they are not altogether pleased with them. On their sidings the trucks have to be knocked about so much in fly shunting, and so on, and those heavy wagons do not lend themselves to that.

11954. You say, in your statement, that the North Western Company and the Great Western Company have built and are running 20-ton wagons on a 12-feet wheel base?—We have seen those for a long time moving about. The Great Western build their trucks for special purposes, and they build trucks for the carriage of their own locomotive coal. That is a 20-ton wagon, and it is a very good wagon, but it has a 12 ft. wheel base. Well, the 12-ft. wheel base will not suit us in South Wales, because all the appliances at the docks and all arrangements with regard to our turn tables, curves, and so on, in some of the smaller collieries, would not be adaptable to them. At one time I did approach the docks to see whether we could not get them to alter, but it is very difficult to do that. With the existing wheel base the existing appliances at the docks can work 12 tons, because I think nearly all their hoists are made to lift 20 tons gross weight.

11955. What is the present wheel base: is it 10 feet 6 in.?—Yes.*

11956. But you have already told us that little by little the size of the wagons on the existing wheel base has been worked up, in fact, from the old 3-ton wagon to the 10-ton wagon, and now to the 12-ton?—And on the North Eastern they have got 11 ton wagons running at the present time.

11957. (*Sir Lindsay Wood.*) And they have some of 20 tons?—You have some of 20 tons on the same wheel base: that is on the 10 ft. 6 in. wheel base. I have that specification here.

11958. (*Chairman.*) It is entirely extra height?—It is extra height almost entirely. There is a little bit in the length as well.

11959. Does the width remain the same?—The width remains the same, practically: they cannot alter the width of the wagons, because you get on the sidings—it is not like carriages—where the fly shunting comes in. Besides that there is the danger to the men: you cannot alter the width without running very serious risk.

11960. I gather that you think the use of 40-ton bogie wagons must necessarily be very limited?—I think they could be used, provided you get the saving proportionate to the extra outlay of capital. It is a question of money entirely if you are going to save. You can use them for point to point traffic. I have an instance here where I think they are going to be introduced into South Wales for taking the iron ore from the side of the ships in the docks at Cardiff.

11961. That is for import?—For import: for taking the Spanish ore up to Guest Keen's works or the other works above on the outcrop to the north, a distance of about 25 or 26 miles. That is entirely point to point: it does not want any extra handling, but it runs simply from the side of the ship up to the works: and for that purpose where you have not to move it about or shunt it, or anything like that, the wagons may be very useful, provided you get the saving in the dead weight proportionate to the live weight to cover the extra cost.

11962. And then you have a big lump to work at—you have the cargo of the vessel to unload?—Certainly.

11963. Therefore every advantage is gained in that instance both in point of speed, weight, and everything else?—Yes, and it is a traffic of iron ore which spreads out better, which does not build up high.

11964. (*Mr. Briggs.*) It is heavy for its bulk?—Yes.

11965. (*Chairman.*) Do you know anything about the West Cumberland district?—I have letters here with regard to that. We are more or less up to-date in South Wales, and so they are in the north, and also in the north-western and north-eastern districts; but in some of the outlying places in what I may call West Cumberland, I find they are still using the old 3-ton wagons, which they used to call chaldron wagons. Of course that does not tend to economy. I have no doubt you will find a corresponding very high rate. I have a letter here from one of the members of our Association, who wrote to me for this purpose, quoting what the rates are. He says, "For 5 miles from the colliery to the dock it is 8½d. per ton"; that is in railway's wagons—in wagons which held about 6 tons.

11966. Have you the rate in the large wagon for the same distance?—No. They have still got those old 3-ton wagons on the Maryport and Carlisle. He says "The rate from the colliery to the dock for 5 miles is 8½d. in railway company's wagons, and 7¼d. per ton in private wagons. The wagons hold about 6½ tons."

11967. That is about 1¼d. per ton?—Yes. Then on the London and North Western Railway, the distance from the colliery to the dock is about 3 miles That, of course, is 8d. That is rather better, and that includes the shipping charge in railway company's wagons, which hold 7 tons. But on the Maryport and Carlisle, there are still chaldron wagons, the tare of which is about 2 tons—and the load 3 tons. It only shows that in some places the people have not been quite as up-to-date as big railway companies in other parts.

11968. Do you think that economies could be made by using heavier locomotives?—That, as you know a great deal better than I do, is a question which you must work out with regard to what the traffic requires. Of course, you do not want to take up a little Yorkshire dale an engine which is capable of taking 1,000 tons weight. We have found this on our own sidings: we have a private railway, which we work, of about 4½ miles, and we work another railway's traffic over it, so that we have

* This applies only to the North Eastern Railway Company's 20-ton wagons. The existing wheel base in South Wales for a 10-ton wagon is 9 ft.

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a certain amount of knowledge as to what the railway working of coal can be done at: we have introduced there much heavier locomotives, but there again we can deal practically from this colliery with fair train loads.

11969. (*Sir George Armytage.*) How many tons?—We take down about 300 or 400 tons at a time if we can get it.

11970. What is the gradient?—It is a very bad gradient: it is about one in 40, I think: but it is with the load.

11971. (*Chairman.*) Still you have to hold it?—That is the only danger: there is a lot of braking, but still it is a short railway down the hill-side, and there is no passenger traffic—no Board of Trade regulations, or anything of that kind.

11972. Have you any views with regard to the general organisation of sidings of railway companies and traders?—All our sidings are laid out so that they are open at both ends, on the principle of the sidings which the North Western Company have up in the north outside Edgehill. With those dead end sidings you are very apt to get your trucks stuck away, and you have to bring out a lot of trucks to get at them. I believe the North Eastern at Northallerton are going in for a fine set of sidings. I am sure if the sidings were more on the Edgehill principle, of using gravity, where you can get it, a good deal is saved.

11973. (*Sir George Armytage.*) They are marshalling sidings, not stowing sidings?—Yes, they are all marshalling sidings: of course all ours are marshalling sidings too.

11974. (*Chairman.*) That is generally done where you have a large traffic; is it not?—Yes. In some places we find our wagons do get stowed away.

11975. The question of returned empties is very important, is it not?—Yes, it is very important, because we have a very large capital tied up in wagons, and we want to get them returned.

11976. Is there any difference between the shipping of coal for bunker purposes and shipping it for ordinary export?—There is a certain amount of difference. The bunkers are more confined: it is not like putting it into the hold, where you can tip it in. The damage done in bunkering ships is not so much in South Wales as it is at Liverpool, London, and so on, because the coal, if it is going from Cardiff, is shipped into the hold of the vessel there, then it goes round to Southampton, is taken out of the vessel there and put into barges, and then the barges go alongside of the ship and the coal has to be taken by hand and put into the vessel which has to be bunkered.

11977. So that it is broken three times?—That is where the damage comes in. I know in some of the men-of-war it is fearful: there are cases where we have to send the best screened possible, and supply it in the largest possible lumps, and it is sent down to a place like Southampton by rail, where it will be taken into a barge: and they have actually paid us to put men on to smash that coal up with a hammer, before they could get it down their shoots. It is partly owing to the construction of these vessels.

11978. You are now speaking of warships?—Sometimes warships, but other vessels are very nearly as bad. Warships put the coal round the boilers in order to be a protection. Well, I do not know anything about it, but I fancy when a warship has been manœuvring before she comes into action a good deal of that coal will be gone—and where is the protection? She will get more protection if the bunkers are put so that the men can get at the coal. I am sure if they could get large Welsh steam coal to put under the boilers they would get from an extra knot to an extra half-knot per hour out of their ship. They smash it up into these little bunkers which are all about the place.

11979. (*Sir George Armytage.*) Is that mostly for the purpose of getting it into the small bunkers, or is it because of the size of the orifice?—It is partly the latter. A passenger ship has very small shoots, too, because everything is sacrificed to the convenience of the passengers.

11980. (*Chairman.*) Are there any canal facilities in South Wales?—There are canals in South Wales, but they are absolutely of no use to us for competition with the railways, because the traffic would be too small; you could not pour a trainload down into the docks in boats. The only place where I know of any decent competition with the railways is on the Aire and Calder, because there they have a very fine canal, and they have a special kind of box boat made in sections by which they are able to take the contents of a long train; the sections hold about 30 tons apiece. I have seen at Goole the hydraulic machinery lift those and tip them into the ship. We have nothing like that in South Wales.

11981. The canal competition is not very effective, is it?—No.

11982. Except in cases where they can get direct to the colliery tips?—We have a canal right alongside our siding with the railways, and we could put stuff on to the canal, but it would be utterly useless—we do not even bring stuff up by it. That is the Glamorganshire Canal. I think I should be rather glad to see it stopped altogether.

11983. Is not the coal liable to break more by being put into the canal boat?—The ordinary canal boat would be no good at all to go to ships. It might do for barging it down, but if the coal was wanted for ships at the port, and if it were going for export, it would be no earthly good.

11984. (*Sir Lindsay Wood.*) Do you think it is any more advantage to the trader to have his own wagons than it is to the railway companies?—Well, it is the advantage that I pointed out, namely, that by having our wagons in our district we can hold them back: it is our look out: we can hold them back or we can keep our collieries waiting Another point I should like to put very carefully is this, that a well-worked colliery would be put to a disadvantage compared to a badly-worked colliery. If we can keep our colliery going by selling our coal promptly, and so on, we shall not want so many wagons; but we find a small badly-worked colliery will never get its ships in time, and never have its business in time, so that it would be always grabbing and holding the wagons. The railway companies may try and get demurrage if they can from people of that kind, but those people would get all the wagons which we would be wanting, and consequently the well-managed collieries would be stopped day after day for want of empties, while the badly-managed colliery would have its wagons full, and coal standing about everywhere. So that it is very essential in a trade like ours that we should own our own wagons.

11985. That must be an advantage to the trader?—Yes, it is.

11986. But must it not be a disadvantage to the railway company to have to sort out all the wagons?—I do not quite see where the difference would come in. Of course, in a district like your own, the North Eastern would serve the whole of a big district, but in a district like ours, where we have to go over so many lines, the Barry, the Taff Vale, the Great Western, the London and North Western, and the Midland, we should be always getting into difficulties if we had any particular railway companies' wagons.

11987. In that case I admit it makes a great difference?—If we could get enough wagons, and if we were always sure of getting every wagon we wanted, I would just as soon that the railway company should go to the capital expenditure of finding the wagons; but I only look at it from a trade point of view, that it would be very doubtful whether we could ever get the wagons we should want.

11988. You would have to have sufficient wagons for your traffic on each separate railway company?—Yes.

11989. (*Chairman.*) Or put all the wagons under one trust?—I have heard that suggested before now; that is, to have a Wagon Trust for the whole of the kingdom—but I doubt whether it would work. It might—I have not thought it out very carefully.

(*Sir Lindsay Wood.*) That is practically the system on the North Western; the traders all own their own wagons in the whole district.

(*Chairman.*) And it is the system which Mr. Shaw puts forward as being necessary in their own individual case; they have 5,000 wagons, and he says they find it a great advantage to have wagons for the whole of their traffic, because they control them.

(*Witness.*) Yes.

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Mr. Joseph Shaw.

17 Mar. 1903.

11990. (*Chairman.*) But you would find it extremely inconvenient if half a dozen railway companies each sent you half a dozen wagons?—Yes. We could not do it in that way; it would stop us. Besides that, there is the question of the number for our particular purpose.

11991. Yes; in fact you do not want the place lumbered up with wagons which would have to wait?—That is so; and we could not load for any particular part; we must load for general trade which may be shifted at any particular moment from one place to another; for instance, if a North Western wagon came in for a North Western train, we should have to shift that down at a moment's notice to Cardiff to fill up a ship, or else pay demurrage on the ship.

11992. Exactly; you want the string of wagons to follow one after another and take their load, and you want to have it in your power to send them to any destination you like?—Yes.

11993. (*Sir Lindsay Wood.*) In the case of shipping small loads in 3-ton or 6-ton trucks, do you know what is the mode of delivery?—I do not know, because it is a long time since I have been up at those places in West Cumberland. I know it more by hearsay, but I could ascertain all about it if you like. The information was sent to me by one of the members of our Committee of the Mining Association of Great Britain, Mr. Fletcher.

11994. In some places the shipping is done by lowering the wagons by gravity on to the ship's deck, and of course you could not do that with a 40-ton truck. That may be the reason why they are still using the wagons of smaller capacity?—I do not know how they are doing it, but I rather fancy from the plans which I have seen of some of the docks up at Maryport that that is the difficulty—because there was a Bill before Parliament for improving those docks not long ago. I happened to be engaged in it for some opponents, and I remember the plans, and I think there were staiths or tipping places there, but whether they lifted the wagon at them or not I do not know. I should have thought they would shoot the coal over the screens in the ordinary way.

11995. Over the tip?—You know the way in which the tips work in South Wales; there are two classes of tips; one is a way in which the truck is lifted up and tipped by a hydraulic machine in such a way that the coal falls out on the screen, and that screen takes it over on to the deck of the ship, and it falls into the hold. The other way is the Lewis-Hunter crane in which the truck runs to the side of the ship and is tipped over into a big box which takes the 10 tons, and that big box is lifted up by a crane and swung over and let right down into the hold of the ship itself. It is supposed to avoid breakage, but whether it does or not has always been a moot point.

11996. (*Professor Dixon.*) In your opinion is that better?—I do not know. Most of the people in South Wales would just as soon go to Barry to ship, because they get the coal just as much smashed either way.

11997. What are the biggest trucks which are lifted right up?—Do you mean in the way I have described?

11998. Yes?—They would lift the modern 10-ton wagon. The modern 10-ton wagon has a tare of about 6 tons 5 cwt., perhaps a little less or a little more, according as the weather is wet or dry; that is 16½ tons. They use these hoists which lift them up by hydraulic pressure and drop them over, or those at Barry, which drop them down. Those hoists could be made to lift 20 tons, so that they could lift 10 tons of live weight easily enough. They are not made to lift more than that.

11999. Would the length of the truck matter in tipping?—Yes, because you have to go into a place like this (*describing tipping operation*).

12000. What is the length of a 20-ton wagon?—The full length over all is I think 14 ft. 6 ins.

12001. (*Mr. Sopwith.*) With regard to the question of ownership of wagons, I take it that your case is applicable particularly to the Midland district. Would it not rather work in this way, that if the railway companies had to supply all their own wagons, they must necessarily have a sufficient quantity to deal with all the requirements of the colliery for putting into stock?—Yes. If they did they would have to find it, or else our collieries would be stopped.

12002. I am speaking of the Midland districts?—I do not know whether we should have an action against them for having stopped us or not.

12003. With regard to the 12-ton trucks, you said strengthening of the journals would be required. Of course that means putting in new axles?—It might mean that; but I think the existing journal we have on our existing specification of 10-ton trucks is 8 inches by 3¼ inch journals.

12004. Am I right in saying that that is the 1889 specification?—I think that is the 1889 specification; I am not quite sure what is the date, but it is the most modern Clearing House specification.

12005. (*Sir George Armytage.*) That is the Clearing House specification for a 10-ton truck?—Yes.

12006. (*Mr. Sopwith.*) In that way you would not require any alteration in the axle?—No, I think that is quite strong enough, provided you are not running at 70 miles per hour, and the road is in decent order, because a good deal depends upon the state and condition of the road and the speed at which you are running.

12007. All that is required for that is to have the specification to apply to a 12-ton truck?—Yes, and Mr. Beasley has written to me saying that they are having a specification got out for a 12-ton truck.

12008. In that case there would be no question about having a fresh skeleton: the wheel skeleton would apply?—Yes.

12009. There is this inconvenience with regard to collieries, about which so much has been mentioned, that is with regard to getting under the screens. I have no doubt collieries would adapt themselves in case of a special industry to have larger wagons, but I should like to ask a question with regard to weighing. There is the difficulty in weighing a 20-ton wagon over a weigh-bridge even if it has a 12 foot base, if the weigh bridge is only adapted for a 10 foot 6in. wheel base?—If the weigh bridge is only adapted for a 10 foot 6in. wheel base and not for a 12-foot one.

12010. It is not adapted exactly, but you could adapt it by weighing the two ends of the wagons?—In our weigh bridge we could take a 12-foot wheel base by making special arrangements, but we could not do it in the way we weigh now. We weigh each truck as it passes the weigh bridge as the train is being made up.

12011. You would only be able to weigh one wagon in the case I put to you?—Yes, you would have to stop the train—it would not be moving.

12012. You mentioned something about an 11-ton wagon; I think it was on the Great Eastern?—On the North Eastern.

12013. Is there any specification for that?—I think there must be. Of course the North Eastern Railway Company have given me the information. I was asking them what their journals were on the North Eastern: the journals of their 20-ton wagons are 10 by 5: the journals of the present 10½ ton-wagons are 8 by 4, and those of the 11-ton wagons are 9 by 4—making it a little bit longer.

12014. What is the maximum weight that you think might be dealt with, having them the same area and getting the increased weight by increasing the height?—I think the maximum that could be done is that North Eastern 20-tonner. I do not think you could put more weight than that on four wheels. That gives you a good weight on each wheel.

12015. And you bring a larger area on the truck?—It is a little bit longer, but it is not the area of the truck that is the question: it is what you calculate to carry on each wheel. If you have only four wheels to carry your 20 tons instead of 10 tons, you have a good lump on each wheel.

12016. But I was taking the ordinary area of the 10-ton wagon?—On the existing area of the 10-ton wagon I should put, as we are beginning to put in South Wales, 12 tons, so as to increase its usefulness by 20 per cent. Then you could go on building that up as the North Eastern are doing, up to 20 tons—that is increasing it very nearly cent. per cent.

12017. That would mean a complete alteration in the specification?—Yes, I would not propose to put 20 tons on our existing 10-ton wagons: you would want to strengthen the journals considerably.

12018. You say the canals in South Wales are of no use on account of the conditions which exist, and that

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the Aire and Calder is the only case in which there is successful competition with the railway?—It is the only one I know of.

12019. I do not know whether you have given any attention to the canal question generally and whether you have any impression as to whether it is practicable to convert canals into large navigable ways?—No, it would be very difficult. You see, one question which I think you would have to take into consideration in doing that would be the question of water supply. Take, for instance, the traffic coming down the valleys in South Wales: if you had to run anything like the millions of tons of traffic that is carried by the Taff Vale Railway, over a canal, you would require a very large quantity of water, because you would lose so many locks-full of water. I do not think you would get enough water in South Wales to do it.

12020. No, but you might in some of the Midland systems; you can pump the water back?—Yes. Then there is the question of cost, and I think the railway companies could beat you there, because they could do it so much cheaper.

12021. The capital outlay would be so great?—The outlay would be very great.

12022. (*Mr. Maclay.*) Is it not the case that just as you have had improved facilities at the ports of shipment you have increased the size of your wagons. You spoke of Cumberland a few moments ago?—Yes.

12023. Is it not the fact that the reason of the bigger wagons being used is improved facilities for shipment?—I do not know. I think there are faults on both sides, perhaps. I think that to a large extent the improvements in the shipping appliances in South Wales have been a little in advance of the others, because now in South Wales they have been able to deal for a very long time at the docks with 10-ton wagons. I see still a large number of 7-tonners running about, but I have got rid of all mine, I am glad to say, long ago. Other companies have some of those old 7-tonners, and they ought to be done away with—the only question is at what price. I think if the dock companies did not give good facilities, that would prevent the larger wagon being used, but I think the dock companies, owing to the competition in South Wales, will always give facilities amongst each other so as to get the traffic.

12024. If the Dock Company gave you facilities for even larger wagons than you now indicate, do you think the collieries would increase the size of their wagons?—No, I do not think so. I do not think the 40-ton wagon will be any good in South Wales, even if they did put up side tipplers. Those are what they use in America, I believe; that is, they run the truck in sideways, and turn it over like that (*describing*), so that the coal all runs off it on to the slides. Even if they did that, I do not think it would be any use, because our trucks must occasionally go into private works, and we find very often small purchasers cannot take 40 tons, because they have not the accommodation to take it. 10 tons is about all they can take, and very often they ask us not to put 10 tons into a wagon.

12025. Do any of the railway companies in South Wales supply wagons to traders?—None—not wagons for coal traffic. Of course they find the wagons for timber at the Docks, and so on.

12026. You made the suggestion that if the railway companies supply the wagons, certain collieries might take advantage of that to retain the wagons?—Certainly.

12027. That does happen in some parts of the country?—I am saying it could happen; I have not gone into that question; I daresay there are other people who know more about the Midlands, but I have known many people who very often wanted wagons, and could not get them from the railway companies.

12028. But my point is this; would not the difficulty be obviated by railway companies adopting a system of charging so much for haulage, and so much per day for the use of the wagon?—But they do that now.

12029. Where do they do it?—Oh, they charge a demurrage. If you hold the wagon back the railway company is entitled to charge for it: I think you are entitled to keep a wagon about four days, and after that they charge you demurrage on the wagon.

12030. But I thought you were dealing with the suggestion that they did not get the demurrage?—Well, it depends whether it is the home line or a foreign line truck. You see if there is a foreign line truck coming in over the Taff Vale from the North Western on to our sidings, it is a matter of arrangement between the Clearing House of the North Western and the Taff Vale; the North-Western would get the money out of the Taff Vale. But if it is a case of a colliery on the North Western, and they are using a North Western truck, the North Western I have no doubt would find it very hard to get demurrage out of the colliery company. In fact I have been in cases and I have advised in cases where these questions have arisen.

12031. That is just the point: would it not be a much better thing for the traders and for the railway companies to change their system and charge so much for haulage and so much for the truck per day?—I see what you mean. I think we have some sort of arrangement in South Wales amongst the traders, that we hire a truck by the day. Very often, if we are short of our own trucks, we borrow trucks from someone else and pay them so much per day. That is what you mean?

12032. Yes.—You mean that the railway company should let out their trucks at so much per day and charge so much for haulage, as we do now when we find them?

12033. (*Chairman*). Is that not practically the result of the method you have described?—It is practically.

12034. You get four days allowed, I think you have said, without extra charge, and after that you pay so much per day?—Yes.

12035. (*Mr. Maclay.*) Then no doubt it should be as you indicate, but the railway companies say that they cannot collect the demurrage. The point is that a change in the system might do away with that difficulty?—I happen to know something about the colliery people in Scotland, and I have often gone into the question of sidings and trucks with them. I do not quite see how you are going to get much improvement. The system you suggest is a system practically the same as is done now.

12036. It does not work out properly?—Because the railway companies on the old lines cannot get the demurrage, and do not like to ask for it, because they fear losing the traffic.

12037. But it increases the cost of working traffic if they do not collect the demurrage.—The railway companies have to do something to make it pay, and if they cannot get the money in demurrage they must get it in rate, I agree.

12038. (*Mr. Young.*) I think you stated that the price of a 30-ton wagon was £340, as against £65 for a 10-ton wagon?—I can give you the figures exactly, because I have a quotation somewhere. I think it was the quotation for a 30-ton wagon, and it was about £320 as against about £65. I think that was the quotation for the last steel frame wagon.

12039. Are they both of the same material?—No, our 10-ton wagons are steel frame wagons; we are introducing them now instead of the old wooden ones; they have wooden sides and wooden ends and wooden floors, but the steel frame means steel side pieces.

12040. Do you know what is the reason that there should be such a difference in the cost, one working out at nearly £11 per ton and the other at £6?—Well, look at the complication of a big bogie wagon; you have to get extra strength for the length and you have 8 wheels and your bogies and all your other arrangements; consequently there is bound to be more cost, as far as I can see.

12041. Could you form or give us any opinion as to the probable life of a big wagon compared with a small wagon?—No, but I should think the small wagon would be better. We have had some 7-tonners, as I say, that we have sold to the North of England. We had them I should think from 1864, or from 1870 at any rate.

12042. (*Mr. Briggs.*) I think your evidence rather tends to show that you believe the maximum weight to be carried on four wheels will be the more convenient thing?—That is what I think.

12043. And not to go into bogie wagons with great lengths at all?—No, that is what I think—for the particular trade.

12044. I am speaking of the coal trade?—Yes.

12045. Are you aware that generally the average truck does carry something like 20 tons on the four wheels?—Yes.

12046. Have you seen them?—Yes.

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Mr. Joseph Shaw.
17 Mar. 1903.

12047. (*Dr. Le Neve Foster.*) On the whole, the pith of your evidence is that you are improving in South Wales, and that you do not want any outside interference?—What I wish is that we should not have any rash thing suggested which will disorganise the whole trade of the country; because I see statements made in the newspapers and statements made at railway companies meetings by people who have had no experience, and who absolutely know nothing about the trade suggesting things which would disorganise the whole of the trade in which I am interested. That is what I mean: I say let us go by steps.

12048. You think you are improving?—Yes.

12049. And that you are improving sufficiently fast?—Yes, I think so. The coal trade is not doing too badly at the present moment.

12050. With regard to the very large lumps of coal which you speak of, which you say have to be broken up, is it not a fact that some of those large pieces would be too big to be shovelled into the furnaces without breaking up?—Oh yes, but this is coal which has to go on board a ship, and it will keep very much better in large lumps on board ship than it will keep in smaller lumps—there is less attrition and so on.

12051. But nevertheless it has to be reduced in size before it gets to the furnaces?—Yes. I have often noticed in my own coal-cellars in London that if you tell the man never to use the hammer, but to throw the lump of coal back on the top of the heap, it is never necessary to use the hammer but it will break itself up by degrees.

12052. Is it not a fact that improvements might be introduced with reference to the combustion of small coal. Is not the small coal chemically as good as the large?—Well, you are going into a very big question about the small coal. I do not propose to say anything about small coal; I may say we are putting up washeries in order to try and deal with it, but the same coal varies so much in every seam: the small coal from some of our seams in South Wales is so filthily dirty and so mixed up with a heavy percentage of ash that it is not worth anything.

12053. I am not speaking of the small coal made in the mine, but of the small coal that is produced by knocking about and breaking?—Yes, that is the small coal that would be made so at the tips at Cardiff.

12054. Yes.—That small coal, if you had furnaces and screens and used it, would be very nearly as good, but not quite; the calorific power would not be so high. I think we had an experiment made with some small coal in London at the electric light works. That is how it worked out. We wanted to persuade one of these people to take some of this small coal; the calorific power of the large coal according to our analysis was about 15lbs. of water evaporated to 1lb. of coal, Aberdare 4 foot, and the small coal was about 10 lbs. of water evaporated to 1 lb. of coal.

12055. But surely those two coals were not the same chemically?—They were not quite the same, because I think the small coal was washed small, and I think there was a little mixture of bituminous coal in it, because it was from our coke.

12056. I am speaking of the large coal, and the small coal produced from that large coal by attrition?—After all said and done, combustion depends upon how the oxygen has to get at the carbon, and if you have a small coal, such as the small Welsh coal, it is a question of the furnace to a large extent; if you can get a furnace to burn it, I daresay you can do it.

12057. Yes, that is my point?—We always use the small coal under our boilers entirely—that is the dirty small coal—but we wash it and clean it. I believe the small people in Egypt prefer to buy what they call screenings at the dock at Alexandria and at Port Said rather than the large coal. They get it a bit cheaper, and it is very pure carbon, because it is small made out of the very big blocks of coal.

12058. They are able to get just as much heat out of it?—Well, that I do not know, because I have not been out there to see, but I rather doubt it, because I do not think you can get the same combustion with the small coal.

12059. Not in an ordinary furnace, but possibly with an improved form of furnace?—I should like to see the furnace first of all; but I doubt it very much, because it depends largely on the construction of the coal. If you take a block of Aberdare 4 foot—the old coal—when it was put on the bars it used to open out and you could see the air going all through it. You will not get the small coal to do that; it will not open up: it is rather inclined to go together; large coal swells. It is exactly the same thing if you put it on the bars; you see the large coal swells and the air comes through, and that is where you get the great calorific power and the quick combustion.

12060. (*Professor Dixon.*) Do I understand that the average price per mile per ton now in South Wales is about ·55d.?—We usually call it about ½d. I say the average rate in South Wales is about ½d. for shipment; that is ·55d. It is a little less in some cases.

12061. And you are quite content with that?—I think it is a fair rate in South Wales, but remember, in South Wales the owners find nearly all the siding accommodation and do all our marshalling. The Taff Vale Company simply comes in, ties the engine on, brings the wagons out and puts a van on at the end and away they go to the docks.

12062. That is where all the trucks and all the sidings are open?—Yes.

12063. (*Sir George Armytage.*) And the gradients are with the load?—So far as the Taff Vale Company are concerned, yes; so far as the Rhymney and the Great Western are concerned, they are not quite so good.

12064. Speaking of raising these 10-ton trucks and making them into 12-ton trucks, would the appliances at the docks be able to deal with those?—Yes; I explained that just now; I think the hoists will be made to lift a gross weight of 20 tons, and that 12 tons, plus the 6 tons 5 cwt. of the tare, gives you a margin of about 1 ton.

12065. Yes; in fact your appliances are for 20 tons?—Yes, they are made for that.

12066. Is that the maximum?—At Barry and Newport I have heard they can lift 20 tons. If I asked Sir William Lewis (I am sorry I do not see him here), he could have told me whether I was right that all the modern appliances could deal with the 12 tons.

12067. Am I to take it as your view that anything above a 12-ton truck could not be dealt with at the port at present?—Yes, at present.

12068. Do you think the inclination of the port authorities is to increase the capacity?—I think such a railway as the Barry Railway, where there would be a saving on the haulage, would begin at once to increase the capacity of their lifts. It can be done at no very great cost as long as you do not alter the whole size.

12069. So as to carry 20-ton trucks?—So as to take a gross weight of say up to 30 tons, that would be the 20-ton capacity.

12070. Yes, what is called the 20-ton truck?—Yes.

Mr. William Scott Barrett, called; and Examined.

Mr. William Scott Barrett.
17 Mar. 1903.

12071. (*Chairman.*) You are, I understand, an Alderman of the Lancashire County Council, Chairman of the Standing Joint Committee and Justice of the Peace for South Lancashire?—Yes.

12072. You are also a member and a past President of the South Lancashire and Cheshire Coal Owners' Association?—That is so.

12073. That Association was established in the year 1843, and represents all the principal coal owners of Lancashire and Cheshire, several of whom are interested in iron and steel?—Yes.

12074. You are also a member of the Executive Council and Honorary Treasurer of the Mining Association of Great Britain, established in 1854, for the express purpose of representing the colliery proprietors and mine owners of England, Scotland, and Wales, and the coal and iron traders generally of Great Britain?—Yes.

12075. You have been engaged in the Lancashire coal trade for a long time, have you not?—For about 40 years.

12076. In what sort of position have you had practical experience of the coal trade?—I was for over 20 years

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managing partner of the Norley Coal Company, Wigan, and I am now acting as commercial manager for the Abram Coal Company, Limited.

12077. The Abram Coal Company is near Wigan?—Yes. I am also Chairman of the Wigan Rolling Mills, which make a considerable quantity of iron in the Wigan district.

12078. Have you taken an active part in representations to and negotiations with the railway companies; for instance, the London and North Western Railway Company?—Yes, my Lord.

12079. That is with regard to docks at Garston?—Yes.

12080. And also you have taken an active part in representations to and negotiations with the Mersey Docks and Harbour Board?—Yes.

12081. Is there any complaint with regard to the facilities at Garston?—The trade at Garston has entirely outgrown the facilities, and for some years past we have urged the London and North Western Railway Company to increase the dock accommodation there and improve the appliances.

12082. Is it a trade which consists of a shipping traffic?—Entirely.

12083. But it is not limited to the particular district?—No.

12084. Is the company taking steps to improve the facilities at Garston?—They obtained a Bill last year to build a new dock, and we had several interviews with them; at the last interview they informed us that the dock was being proceeded with, and that the appliances would be of the most modern construction.

12085. Is that the case where delay was caused by a Bill of theirs being thrown out?—Yes. They did not do something they ought to have done, or were supposed to do, with regard to housing; and the Bill was thrown out in that year on that ground.

12086. It was subsequently passed?—It was subsequently passed at a later session.

12087. Is there a group-rate applicable to Garston?—There is a group-rate of 1s. 2d., plus 3d. for dock dues, which makes it 1s. 5d.

12088. What is the effect of that group-rate upon the district?—It has made an enormous increase in the shipping at Garston.

12089. Although it makes the rate per mile vary at different collieries in your different districts, does it?—You see all colleries that are on the group-rate, no matter what the distance is, get it for 1s. 2d.

12090. Therefore, as I say, *qua* distance they would get varying rates?—That is so.

12091. Do you think the group-rates are advantageous as regards shipping and so on?—It is proved to be so in this case.

12092. (*Sir George Armytage.*) Do you mean generally, or from the colliery owner's point of view?—From my point of view as a colliery owner.

12093. (*Chairman.*) Are they satisfied even although one man gets his coal carried seven miles further than another?—Well, not in this particular case, because Garston is a natural shipment port for a certain quality of coal, and unless there was a low rate the coal could not be shipped there, and therefore it suits the various collieries who have that particular class of coal to send.

12094. Has the shipment from Garston largely increased of recent years?—Yes, enormously; it has increased from about 190,000 tons in 1871 to between 1,000,000 and 2,000,000 tons, at present.

12095. I suppose if a new dock is built the most modern method of shipment and of dealing with the coal would be adopted?—That is so. The London and North Western have gone into that question and they have told us that the most modern cranes and tips of every description will be provided.

12096. Does coal go to Liverpool for shipment from your district?—It does; it goes to the High Level at Liverpool and the Herculaneum, the High Level being on the London and North Western system, and the Herculaneum on the Cheshire Lines.

12097. Are the arrangements at those two places, the High Level and the Herculaneum, good?—They are very good as far as they go, but they are not sufficient for the amount of traffic that can be got there.

12098. You mean they are not sufficient as regards capacity and method of dealing with it?—Not method, but capacity of dealing.

12099. In fact, the accommodation, you would say, wants extending; is that it?—Yes.

12100. (*Sir George Armytage.*) Is there any area in which to extend it?—No. I should like to say this. In 1873 the Dock Board of Liverpool had a very extended scheme of docks, and they promised us then a coal dock, both at the north and at the south end. The High Level then was admitted by everybody to be quite inadequate to the requirements of the coal trade. They enlarged the High Level by putting large loading berths at right angles to the then existing High Level. Since then they have opened the Herculaneum Dock; but the original plan of the two docks for coal which we were to have had has never been carried out. But the enlargement of the High Level, of course, has permitted a very much larger quantity of coal to be shipped there than used to be at the old High Level.

12101. (*Chairman.*) Is there more shipping at the High Level than at the Herculaneum?—I should think so. I have no figures to show that, but that is my opinion.

12102. But I understand you to say that, although the High Level is deficient, it is difficult to extend the accommodation?—That is so. I do not know whether I made it plain; the docks where the High Level is are used for other purposes besides coal, and they can only get ships in to load at the High Level when there is room in the dock for them.

12103. (*Sir George Armytage.*) The Herculaneum Dock has a greater draught, has it not?—Yes, that is so.

12104. (*Chairman.*) You say that at the present time in the case of coal shipped in docks other than the high Level, or the Herculaneum at the south end of the Liverpool Dock system, or at Garston, the coal has to be shipped into the vessels in baskets, and in many cases the weight of the coal put on board has to be judged by the weight in each basket?—That is so, my Lord.

12105. That is surely very antiquated, is it not?—Most antiquated. Of course that only obtains to a very small extent now. But where vessels are loaded apart from the Herculaneum, the High Level, or Garston, where the ships will not shift their berths, the coal is brought in flats or barges and has to be basketed up the side of the ship.

12106. Is that for bunker coal, or is it for both kinds?—Both. We send a quality of coal called cannel-coal abroad, and when we have not sufficient to induce a steamer to go to the High Level to load, we have to load it out of boats up the side of the ship, and then it has to be handed down into the holds in baskets.

12107. (*Sir George Armytage.*) On the other hand, is there not a certain amount of loading done by cranes?—Yes, a certain amount.

12108. (*Chairman.*) Is there any difficulty or delay in dealing with the traffic?—Do you mean by the railway companies, my Lord?

12109. By the railway companies?—We find a difficulty in getting the wagons returned very quickly, I made out a statement of the delays to our wagons, and we find that, whereas in November, 1897, the average trip per wagon used to be 3·92 days, in 1902 it was 4·59 days; and, of course, on a large number of wagons it means a very great difference per year to us.

12110. (*Sir George Armytage.*) Is that at the Herculaneum or at the High Level?—It is generally.

12111. (*Mr. Young.*) Taken over the 12 months?—Yes.

12112. (*Chairman.*) Have you reason to think that the railway companies are in any part to blame in regard to that. May it not be that the railway companies cannot get the wagons unloaded?—In that return we do not count delays to ships by fogs, storms, and so on; we take the actual time of the wagon between leaving our place and coming back again. What we find is that the wagons do not arrive at their destination as soon as they should after leaving our place, and another thing we find is that the railway companies, or some of them at any rate, do not send back the wagons until they get a full train load. Therefore wagons wait until an engine has been able to accumulate what they consider a full train load.

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Mr. William Scott Barrett.

17 Mar. 1903.

12113. (*Sir George Armytage.*) Do you send a full train load?—Not in all cases. We do for shipment, but for wayside stations we do not.

12114. (*Chairman.*) Is your coal sent entirely in your own wagons?—Entirely in wagons of our own—except locomotive coal; where we supply locomotive coal the railway companies supply their own wagons.

12115. Quite so; but whether for the local traffic or for shipment all your coal goes away in your own wagons?—That is so—in our own or customers' wagons.

12116. Not railway wagons?—No.

12117. Do you get any canal facilities?—I may say practically we have none. The Leeds and Liverpool Canal runs through the colliery district, but it is very little used now compared with what it was many years ago.

12118. Is there any explanation of that. Is it not as convenient?—What we think is that some years ago this canal was leased to the Lancashire and Yorkshire Railway Company for a term of years, and during that period the canal company were assured of a certain income from the railway company for the use of this canal. They apparently simply took the dividend, or took that price, whatever was paid for it, and they did not improve their canal at all; and, it being under the control of the railway company, they had no inducement to offer facilities for coal or dock traffic, or anything else, and when the canal went back into the canal company's hands it was silted up to a certain extent, and they did not seem disposed to spend the amount of money that would be required to put it into good order. Since then the canal has practically gone down very much indeed as a carrier of coal, and it is not, as it used to be, a sort of alternative to the railway.

12119. Then, the Lancashire and Yorkshire Railway Company having taken it over, a sort of blight fell upon it. Is that your view?—That is the effect.

12120. (*Sir George Armytage.*) The fact is that it was doing better work in the Lancashire and Yorkshire Company's hands than it was in the hands of its old proprietors? — Well, the result is that it is not doing as good work as it was before.

12121. They are short of water, are they not?—Yes, dreadfully short.

12122. And what water they have goes down into the coal pits, does it not?—I am afraid some of it does; we have to pump it out. But they are so short of water that in the summer time we had to send boats half loaded. Then the Sankey Canal was formerly used between Warrington and St. Helens; that is now in the hands of the London and North Western Railway Company, and that is practically no use as a coal canal. It is principally used by the Sankey Sugar Company, I think.

12123. (*Chairman.*) Is the coal traffic in Lancashire principally a short distance traffic?—I should think 30 miles is about the average in the Lancashire coal trade.

12124. Do you think that large wagons are practicable in that district?—Larger wagons for some purposes might be practicable, for instance, for locomotive coal But that the traffic of Lancashire could be worked in large wagons I think is impossible. We have a great many merchants, especially at wayside stations, who take small quantities of coal, to whom a 15 or 20-ton wagon would be absolutely useless. Then we have many works that take slack from us, whose fire-holes are not adapted to a wagon of that size, and in addition to that we are obliged to have different kinds of wagons; for instance, if you take the High Level at Liverpool, they have three systems there: they have one where they can load into flats through a shoot, they have one where they take large wagons and lower them down to the vessel, and they have a third crane where they take dock wagons; when they get to the tip the bottom is lowered down and the coal goes into the hold. You could not use a big wagon at all those places, they would only be used for a particular purpose, and could only be tipped exactly where the arrangements were adapted for them.

12125. Then it is your opinion that for the wayside station traffic those wagons could not be used?—I do not think they could, my Lord.

12126. Could not a coal merchant, although his separate and individual orders might be less than, let us say, even 20 tons, take 30 tons, as has been suggested, and share it with two others? — I think that the ordinary business rivalry between coal merchants would prevent that. I do not think they would combine together to do that; they would each be afraid of the others knowing too much of their business. I do not think that is practicable.

12127. You think that, as has been suggested with regard to agriculture, for example, putting their quantities together and so getting the large and heavier loads, is not practicable?—I think if three farmers choose to combine together, for instance, they might order a big wagon amongst them, but I do not think that three coal merchants would.

12128. You could not keep the coal all separate, I suppose. It might not be all of the same quality?—Unless you had the wagon divided into three, I do not think you could. But three merchants in the same place would be hardly likely to deal with the same colliery; as a rule they deal with different collieries: I mean there would be very few collieries which would have in one small place three merchants all on their books.

12129. Do you get to know in any way where the coal is sent to?—I have the entire distribution of our coal, if you mean that, my Lord.

12130. I did not make clear what I mean. Supposing I am a coal merchant, and I contract with you for 500 tons of coal, and I send you orders from time to time to send me so many wagons; do you get to know in that way to where the coal goes?—Do you mean the individual it goes to?

12131. Yes.—No, except that it goes to a mill or something of that sort; a man will make a contract with us, say, for slack.

12132. With regard to the labelling of the wagon, for instance: is that done by you or by the merchant?—It is done by us, but it is only done to a station: it does not say to whom the coal goes except in very few cases.

12133. Therefore you might know the station it was going to, but you would not know anything beyond that?—Unless it was a contract for the mill, when they would specify which particular mill it was going to. If there was a wagon-load, for instance, it might be divided between three or four different customers.

12134. There are points, take for instance Peterborough, where coal is sent, as I understand, to await the order of the merchant, as it is called, whose coal it is, and then he distributes it from there it may be into the eastern counties, or to the south or to various places?—I do not know of anything of that sort in Lancashire.

(*Chairman.*) No, it is a costly buisness.

12135. (*Sir George Armytage.*) I understand generally your view is that the present size of trucks is sufficient for the work of your district?—I would scarcely like to say that. I should like to say that there may be larger trucks, but there must be a large proportion of the present size of trucks for the trade that we are doing.

12136. Putting aside the question of locomotive coal or shipping coal in large quantities, what do you consider the size of the truck which is most adaptable for all the collieries of the district?—I should say not above a size that would carry 15 tons.

12137. Do you think that if 15-ton trucks were used the colliery appliances would be made to suit them? Do you think it would be to the interest of the colliery proprietor to alter his screens, curves, turn-tables and that sort of thing?—Not unless they were going to be used almost exclusively. I do not think it would pay him to do so. Then, of course, Sir George, you know very well that at the High Level and the shipping places they could not take such big trucks There are only about two cranes that take trucks of that size and discharge them.

12138. Do you know what is the largest crane that is in use at Liverpool?—I think there is one crane at the High Level which takes 25 tons.

12139. By swinging the truck up?—By swinging the truck up; and I think there is one at Herculaneum; but I do not know of any other place round Liverpool where they could take a truck of over 20 tons.

12140. What is the largest truck that you know of in your district which is used by the colliery proprietors as a private owner's wagon?—About 12 tons.

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12141. Is that a 12-ton truck on what they call the Clearing House specification, or is it an enlarged truck such as we heard of from the last witness?—I think it is on the Clearing House specification, because I do not think the railway company would allow us to run anything that was not on the Clearing House specification; it would be stopped at once by the joint railway companies.

12142. Have you any opinion as to the desirability in the future of the colliery proprietors owning trucks, or the railway companies owning them?—Personally, I should be very much averse to the railway companies owning them.

12143. (*Chairman.*) Would you tell us why?—If you take our own colliery, we are on two systems, the London and North Western and the Cheshire Lines, and we send a large quantity of cannel coal to South America. Suppose we are ordered by our customers to charter a steamer, or part of a steamer; we go to the people in Liverpool who own the large steamers sailing to South America, and they give us a boat conditionally; that boat may be at Garston; then, before the time comes for loading they may have changed that boat for one at Herculaneum, and if we have wagons, we will say, on the Great Central to load at Herculaneum they would not like us to go to Garston to load on the North Western line, and it might therefore be that we should have to discharge these wagons into North Western wagons in order to send them to the line to which they belong.

12144. What I had in my mind at the moment, and what I think was in your mind, was this; supposing the wagons were interchangeable and they were available, whatever company they belonged to, for all purposes; would that remove your objection?—To some extent it would.

12145. That is your point?—Yes.

12146. (*Sir George Armytage.*) But you have not quite got to the objection. What I understand is that you say you would rather the railway companies should own the wagons?—No. My view is exactly the opposite; I think the colliery owners ought to own the wagons. There is another thing; I think it would be almost impossible for a colliery company to carry on a colliery if they were dependent upon a railway company. I do not say for a moment that the delay is always the fault of the railway companies, but there may be delays in sending wagons, in which case it would absolutely stop the colliery.

12147. Of course no one could suppose for a moment that the system suggested could be carried out unless there was an ample supply?—Just so.

12148. But supposing that all the wagons in the country were put into one great trust, and that they could be dropped about the country in just whatever way was most convenient, and that you were guaranteed a proper supply of wagons; what would you say then?—I do not think a trust of that sort would find sufficient wagons. When a colliery is laid out, a prudent owner, so far as I know, provides more wagons than he thinks he would be likely to require, so as to cover contingencies: but if there were a Wagon Trust Company they would be more likely, I should think, to provide a limited number of wagons to work the trade.

12149. I mean assuming there are enough?—If there is an unlimited supply, and they could be got anywhere, there would be no objection to it at all.

12150. Would you prefer it to the present system?—Personally, I should prefer the colliery owner to have his own wagons.

12151. Then, if he has his own wagons, and he runs short, it is his own fault?—Yes, because I think the prudent colliery owner would provide for emergencies.

12152. You keep a separate account of your wagons, I understand?—Yes.

12153. Do they pay you a reasonable rate of interest?—No. We consider them an adjunct to the colliery. That statement I have made just now about the delays makes a difference of £1,500 a year to us in our wagons: between the 3·92 and the 4·59 on our wagons the difference makes a difference of £1,500 a year to us.

12154. Quite so, but you can easily understand that, because railway companies not only carry your coal at a certain rate, but they also have their lines burdened with the coal wagons?—No doubt that is so.

12155. Do you not think there might be a great reduction of haulage if the wagons could be used more conveniently amongst the different collieries?—That might be so. *Mr. William Scott Barrett.* 17 Mar. 1903.

12156. (*Chairman.*) Would your objection to what has been called a Trust in the question put to you be this; supposing the colliery companies put their wagons together, would there not be a saving, and a larger supply for everybody if the supply were dealt with as a whole rather than dealt with in separate units. Let me put it in this way; supposing there were 20,000 wagons owned by ten collieries, possibly one having 4,000, another 3,000, and another 1,000, would not the 20,000 wagons be capable of a greater service if they were available for the whole of the ten collieries than the separate proportion of the total 20,000 for the separate collieries?—No doubt if the system was carried out efficiently, that would be so, my Lord; but of course there is a great deal of selfishness in all business, and everything else. To take our own case, for instance, when we ship cannel to South America, we ship it, we will say, about 2,000 tons at a time. We know from our experience when it is likely to be required, but sometimes we cannot get a steamer, for instance, if these large Liverpool liners have got sufficient cargo to take out, they will not take our cannel; they take it more as ballast than anything else. Well, we know that presently it will be wanted, and we have as much as 2,000 tons at a time waiting for a fortnight, knowing that we shall get it away in time.

12157. But that rather emphasises my point, does it not, because you take that 2,000 tons out of the limited quantity of wagons, and it leaves you, therefore, only the difference between that and the total number from the particular colliery?—But I take it, that, supposing the trust which has been suggested had these wagons, they would charge us so much per day for borrowing them.

12158. But it would all go into your own pockets in the same way; it is only out of one pocket into another—that is all. My point is, must you not have a margin of wagons for the requirements of every separate colliery?—No doubt.

12159. That puts what I mean?—Yes, no doubt that must be so.

12160. With that margin for accident and for the purposes of safety and surplus, and so on, would it not be possible to use a portion of that margin or to use that margin to a certain extent in everyday work, if they were controlled and used for the whole of the collieries, rather than being held in the proportions that have been suggested?—Of course, if worked perfectly, it would be so, but what I am afraid of is that if a colliery loses the individual control of the wagons, which they have for their own purposes, they might be left in a corner sometimes without wagons.

12161. But under the system which I suggest they would not lose the control for their own purposes at collieries. I think I can see what is in your mind, that supposing the wagons were owned by the railway companies, and the colliery company had no voice in getting their fair share, you might say then you would be at the mercy of someone else to your own disadvantage?—Yes.

12162. But what I meant rather was a combination of the whole of the wagons, let us say, of the Lancashire coal owners, put into a trust or a pool, or whatever you like to call it; the benefit of which should accrue in proportion to the wagons. It would be merely out of one pocket into the other. Would it be possible to use the 20,000 wagons to a greater advantage in one lump of 20,000 with that control, so as to be able to send them anywhere and use them for all purposes both going and returning, as compared with 10 separate 2,000s?—I think in the long run it might pay better to do that, but I think there might be times when individual collieries, not having the control, would be in difficulty.

12163. (*Sir George Armytage.*) If the wagons did stand idle unnecessarily they would pay rent?—Yes, the financial result might be satisfactory, but it might happen that the colliery would be deprived of wagons just at the time when they most wanted them.

12164. (*Chairman.*) Of course it might be that one colliery would be busy, and therefore could use to-day a larger number of wagons, and another colliery might be busy to-morrow, and would want a larger number of

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Mr. William Scott Barrett.

17 Mar. 1903.

wagons. Would it not be more elastic if you had the total number to draw upon, so that you could send 200 to a particular place, whereas a colliery near might have only 200 of its own on a particular day?—During the last winter when the storms have been very severe indeed, we have been as much as four days without a vessel of any sort, when they could not move out of Garston or get into dock.

12165. Then you must have a larger number of wagons in which to put your coal?—Then perhaps when the storm subsides half a dozen vessels will come at once and the wagons all go out. Unless we had full control in such a case and were able to get our wagons back again, everybody might be pressing for them at the same time, and that is what I should be rather afraid of.

12166. (*Dr. Le Neve Foster.*) What is the reason of those antiquated arrangements at Liverpool which you have spoken about, such as loading in baskets?—It is the old system which was in use when the coal was sent down by canal. The coal was sent down by canal and loaded out of the canal flats by baskets up the side of the vessel, and that is the only way that obtains in Liverpool in loading vessels, unless they load at some of the modern places, such as Herculaneum, Garston, or High Level, where there are tips to load the ships.

12167. Is not that accommodation enough for them?—It is not only that : perhaps a large vessel which is taking in a few thousand tons of coal will not move into another dock : it costs more to move into another dock than to have the barges sent alongside the vessel : I mean a large American liner, for instance, taking thousands of tons of cargo would not move for the sake of 500 tons of coal.

12168. What would you advocate—better loading arrangements at Liverpool?—Better dock accommodation at Liverpool. What we have always wanted in Liverpool is a coal dock which could be exclusively or almost exclusively used for coal and from which all the coal could be shipped.

12169. Which does not exist at the present time?—Quite so.

12170. What is the reason why the delay in the return of the wagons should be greater now than it was say four or five years ago?—I cannot say. We think one of the reasons is that the engines do not go back unless they get a full train load. In the old times they used to go back oftener. Of course there are very much larger and more powerful engines being used now, and where they have those very large engines, they perhaps want to bring back 40, 50, or 60 trucks, and if they are stopped by waiting for a full train, there is naturally delay in getting wagons back to the collieries.

12171. (*Mr. Briggs.*) That means to say that the economy which the railway company have been making by means of long train loads has to some extent hit you as regards your wagons?—We think so.

12172. And you have had to pay something of that in wagon hire in so far as you provide the wagons?—That is so.

12173. It would be therefore more satisfactory in that regard, that if the railway company did provide the wagons it should be at their own cost, and that would meet their own convenience?—They would have as little delay in that case as possible.

12174. Is there not an inclination now for people to keep on working to the last gasp with so many wagons, and if you had fewer wagons you would send them a day earlier, so that it would not amount to much in the long run?—There would be a difficulty in asking a trust, if there was a trust, for the sufficient supply of wagons, because you do not always know how many you require.

12175. As a matter of fact you do pay as a coal owner, do you not ; I mean you provide your own wagons, so that if you keep them standing they would cost you so much ; exactly the same as if they were in the hands of a trust?—Exactly ; they would cost a certain amount, of course.

12176. (*Mr. Maclay.*) Would it not be a very great incentive to the railway companies to bring the wagons back more quickly if the wagons were their own?—I suppose that would be human nature ; I think it would be so.

12177. Your impression is that they would do it?—I have no doubt that they would make the best of them that they possibly could.

12178. You spoke about the new dock at Garston. Do you know what appliances they are going to give there for loading—I mean the size of wagon they intend to provide for?—They told us when we saw them that they intended to provide the most modern construction tips and for the largest wagons that were likely to be sent. They also told us that the chairman and several of the directors had been down to the various shipping ports in order to ascertain what was the most modern and efficient system of tips anywhere.

12179. They did not indicate the size or weight of wagon?—No, they did not.

12180. You have no idea of that?—No.

12181. What size of wagon do you use now?—Our biggest wagons in Lancashire are 10 tons—as far as we are concerned.

12182. With regard to the group rate which you mentioned, what are its limits?—About 30 miles.

12183. Do you know the shortest distance from any colliery to Garston?—Speaking roughly, I should say about 19 miles.

12184. And what is the longest?—About 31 miles. That is my impression, but I would not like to bind myself to those figures.

12185. And the coal is carried to Garston for the same money?—Yes, if you wish to have those figures exactly I will get them for you, because I do not know absolutely what they are.

12186. (*Sir George Armytage.*) Is that group rate for a period of years or for all time?—For all time. I do not know whether you are aware that the railway was made by the colliery proprietors ; it was called the Lancashire Union Railway, and it was sold to the North Western Company, and one of the terms was that the rate should be in perpetuity 1s. 2d. and a 3d. rate for the use of the dock.

12187. (*Mr. Maclay.*) And that was approved by Parliament?—Yes.

12188. (*Sir George Armytage.*) That practically governs the rate?—Yes.

12189. (*Mr. Sopwith.*) Was the Leeds and Liverpool Canal of much benefit to the district before being taken over by the railway company?—There was an enormous quantity of coal and slack shipped to Liverpool in the old days, and in those days there were very large works on the canal banks and coal yards at Liverpool, all of which did an enormous trade ; in fact, most of the coal that came into Liverpool for works and household purposes was brought in by the canal.

12190. How long was the canal leased by the railway company?—I do not know of my own knowledge, but I should think perhaps 15 or 16 years.

12191. Dating from when?—I am afraid I cannot give you the date.

12192. (*Chairman.*) By the way, how was it terminated, was it by the railway company or by the canal Company?—I believe I am right in stating that there was an agreement with the railway company for a period of years, and it certainly was in existence from 1865 to 1875, but what the period was I could not say exactly. I know this of my own knowledge—because we used to have large quantities of timber come to our colliery which we got from Ireland, and the vessels that then came had what we call bow ports—we got large poles.

12193. But you do not happen to know whether it was the canal company that wanted to get more out of it or whether it was the railway company?—I do not know anything at all about that.

12194. (*Mr. Sopwith.*) Did the traffic fall off gradually during the lease?—It fell off gradually during the lease.

12195. Were there covenants to maintain the canal —because you have mentioned in answer to Sir George Armytage that water was getting into the mines—did that take place during the time of the lease or is it a matter that has been going on for a long time?—It has been going on for a long time.

12196. Because in South Staffordshire, which is the most exceptional instance in England of canals being undermined at shallow depths, they have been able to maintain the system of canals perfectly well. There would be no reason why the Leeds and Liverpool Canal should not have been kept intact without allow-

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ing the water to go underground?—The Leeds and Liverpool Canal is perfectly navigable for boats now.

12197. But you said in summer there was a shortage of water?—Yes.

12198. I understood that that shortage of water was perhaps due to the leakage of water?—No, that is not so. They have large reservoirs in Yorkshire and those reservoirs get dry in summer time. That is what made them short of water.

12199. But that would exist previously to the taking over by the Lancashire and Yorkshire Railway Company?—No doubt.

12200. That was a defect which existed before—that had been common in all seasons?—In any dry season that naturally would be so.

(*Chairman.*) The whole tendency is for the land to be drained. The supply of all those streams is much less than it used to be.

12201. (*Sir George Armytage.*) I think I am right in saying that the canal runs right through Wigan?—It does.

12202. And they keep on banking up and banking up because they have allowed the coal to be got?—Yes.

12203. They had the option of buying the coal, but they have not exercised their option, and the consequence is that the whole of the ground has gone down, and they continually try to keep the canal up by raising the banks?—That is so.

Mr. William Scott Barrett.
17 Mar. 1903.

12204. (*Mr. Sopwith.*) If the canal is of great service there is room by pumping or by greater enterprise on the part of the canal company to maintain the water in the canal and that canal would then become of greater service than it is now, by reason of its having been allowed to become to a certain extent, you may say, almost derelict?—I think so.

12205. (*Chairman.*) Is the rate less by canal?—We paid from Wigan 8½d. for a distance of 33 miles; I think it was about a farthing per ton per mile.

12206. (*Mr. Sopwith.*) Are they carriers, or do they only charge tolls?—They are carriers of goods, but with regard to coal they were only toll takers. In the case of coal we provided our own boats, horses, and everything else.

12207. There is no chance of its being resuscitated?—No.

12208. You would not like to pay a farthing per ton and provide your own boats now, would you?—No. As far as Liverpool is concerned the coal yards are things of the past. When the canal got into disuse the coal yards were sold and there are none now. There also used to be large alkali works, which went to Widnes. The gas works of the Liverpool Gas Company are on the canal bank at Linacre, but owing to the canal rate they established a junction with the Midland Railway Company and now a large quantity of Yorkshire coal comes in which used to come by canal from Lancashire.

12209-10. Then there is no special object in putting the canal right now, because of the disappearance of the yards?—Yes, that is so: but still it was a kind of competition, which I think has now gone.

TWENTIETH DAY.

Wednesday, 18th March 1903.

PRESENT:

The CHAIRMAN.

Sir GEORGE ARMYTAGE.
Sir LINDSAY WOOD.
Mr. BRACE.
Mr. BRIGGS.
Dr. LE NEVE FOSTER.
Professor LAPWORTH.
Mr. MACLAY.
Mr. SOPWITH.
Mr. YOUNG.

The Secretary.
The Assistant Secretary.

Mr. GORDON WILLIAM MILLER, C.B., called; and Examined.

12211. You are large purchasers of British coal for the Navy, are you not?—Yes.

12212. Could you tell us what the expenditure is—that is to say, expenditure in the sense of consumption?—The consumption of Welsh coal during the present financial year will approximate to 1,000,000 tons, that is, of steam coal for the fleet; but this expenditure is gradually increasing year by year. We consume about 60,000 tons of North Country coal for dockyard purposes. We also obtain coal to the extent of about 100,000 tons at foreign stations, mostly from Australia and New Zealand.

12213. Is that independent of or in addition to coal which is either stored by you at foreign stations or contracted for outside the kingdom?—These quantities are irrespective of stock. Some of this Colonial coal is stored as well as Welsh coal; for instance, at Hong Kong we store a considerable quantity of coal that is obtained in New Zealand.

Mr. Gordon William Miller, C.B.
18 Mar. 1903.

12214. Is the Admiralty purchase or consumption of coal increasing otherwise than by the multiplication or increase of the number of vessels?—The consumption of coal in the Navy has very considerably increased in the course of the last few years, due to the increase in the number of ships, to the alteration of types of ships, and to increased power; and to movements of ships being greater than in the past.

12215. Have you any figures showing what it was 5 or 10 years ago?—Yes, my Lord. The total consumption of steam coal in the Navy in the year 1893-4 was about 450,000 tons; 5 years afterwards, in the year 1898-9, it had risen to 710,000 tons; in 1902-3 the estimated expenditure was rather over 1,000,000. For the year 1903-4, it is expected that it will be a little short of 1,250,000 tons. That shows a very rapid increase.

12216. Yes, it is quite a large increase. According to that it is doubled in 10 years?—More than that, my Lord.

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Mr. Gordon William Miller, C.B.

18 Mar. 1903.

12217. And apparently the rate of increase is higher now than it was then?—Yes.

12218. That is to say, progress in tons, although not in percentages?—Yes, in tons. There have been large increases in the fleets at foreign stations as well as at home, which probably account for a part of it.

12219. When you speak of North Country coal used for dockyard purposes, do you mean for land boilers?—Yes.

12220. Is your consumption of coal, or your purchase of coal, I will call it, for your foreign stations from what you call local sources—that is to say, sources other than this country, as I understand—increasing?—Purchases abroad?

12221. Such as Australia and New Zealand?—Yes, it has increased of late, partly due to increase of the stocks abroad; with increased fleets we have increased stocks; increased consumption also requires an increased stock to meet calls. For instance, in China, where the fleet has been largely increased, we have had a commensurate increase of stock; and also in the Mediterranean.

12222. Of course, 100,000 tons is the quantity, as I understand, purchased from places like Australia and New Zealand?—Yes.

12223. But that, of course, does not represent your consumption of coal at foreign stations?—Oh, no; that is in addition to the quantities of Welsh coal we send out from this country.

12224. Quite so; but the quantity of Welsh coal which is sent out from this country is included in the 1,000,000 tons figure which you gave us first?—It is, my Lord.

12225. Is the Admiralty coal obtained from a large number of collieries?—At present we obtain the coal from 24 collieries.

12226. They are in South Wales, are they?—Yes.

12227. Have you any sort of estimate as to the production of coal in the South Wales district of the quality which is suitable for your purpose?—From the information that we can gather, the total output of those collieries which supply us is about 13,000,000 tons per annum.

12228. (*Mr. Brace.*) Would you have any objection to giving the names of those collieries?—There is no objection to giving a list of those collieries, because they are all included in the tender forms that we circulate.

12229. (*Chairman.*) And the tender forms are made public?—They are in the case of coal supplied through contractors abroad.

12230. Quite so?—We bind contractors down, with regard to supplies abroad, to certain collieries. The tender form contains a full list.

See Page 155.

12231. Then perhaps you will kindly send us that list?—I will.

12232. (*Mr. Sopwith.*) I suppose those vary in different years?—No, they vary to this extent, that the list may be added to. It is rarely that collieries are taken off; it is only when the coal has fallen off in quality.

12233. (*Chairman.*) The method is that you make certain tests if a colliery wants to be put on your list, and if the tests are fairly satisfactory I suppose you put the colliery on your list?—Yes, after an extended test in the fleet.

12234. When you spoke of 13,000,000 tons as being the output of the collieries from which you obtained your supplies, did you mean the total output of the collieries, or the total output of those collieries of the kind of coal which you are able to use?—Only the output of the 24 collieries which supply us with coal. I understand that, roughly speaking, the annual output of all the collieries in South Wales would be about 30,000,000 tons, and, I think, of Monmouthshire coal about 10,000,000 tons.

12235. Then are we to understand that the collieries from which you obtain your supplies, or collieries producing the quality of coal which is suitable for you, produce that coal only? That is rather my question?—Yes, the collieries produce that coal only, but some colliery owners possess other collieries as well from which we do not obtain coal. These are excluded.

12236. Therefore, really putting the figures in that form, your purchase is about 1-13th of the whole production of that kind of coal?—That is so, my Lord.

12237. Could you tell us what the conditions are which govern the selection of collieries from which the Admiralty coal is obtained?—The chief naval requirements in connection with the coal are its calorific efficiency, smokelessness, cleanness, hardness, free burning, minimum of ash and clinker, and the coal should not cake or give trouble in stoking.

12238. Has smoke much to do with it?—Yes, smoke has a great deal to do with it. We endeavour to obtain coal which gives off as little smoke as possible. It is found on occasions when observation of a fleet is necessary from a distance, that a fleet giving off a lot of smoke can be detected at a much greater distance than if the smoke were small in quantity. That is considered to be of great importance in connection with the supplies of coal to the Navy; smokelessness is one of the principal tests.

12239. In fact, the power of concealing your proximity?—Yes.

12240. The considerations which you have just described to us which govern the question apply, as I understand, when you speak of naval requirements, to the requirements of the ships at sea?—Yes.

12241. And that, of course, has no reference to the coal which is used for land purposes ordinarily?—No, not at all.

12242. I do not know whether you could answer this question or not: Do the War Office buy any of this coal?—A small quantity—some 6,000 tons annually, I understand.

12243. You have nothing to do with the purchase if they do?—Oh, no.

12244. Is anything being done to extend the area of supply?—Yes, that object is kept constantly in view. We have six descriptions of Welsh coal under trial at the present time—under various stages of trial—and we are trying mixtures of the drier and bituminous coals which are found in the Welsh district. They are obtained from outside the area of the Welsh coalfield that we are now drawing from. We think, possibly, that if a satisfactory mixture of drier coals and bituminous coals could be brought about, it might possess the properties we require.

12245. That is to say, that it might possibly double your area of supply?—It might considerably extend it. There are coals in South Wales of too dry a character for use in the Service, and there are also the more bituminous coals that are not useful for the Service, on account of the smoke chiefly. We think possibly by bringing the two together we might increase our area of supply. Of course, there are difficulties in mixing coal, but they are not insurmountable. We are also carrying on further experiments to ascertain whether the furnaces of ships can be adapted to burning bituminous, such as North Country, coals.

12246. Do you mean separately or together, or both?—Separately, and they will probably be followed by trials of anthracite mixed with bituminous coals. Experiments are in contemplation also with anthracite coal in conjunction with oil fuel.

12247. Have any experiments been tried in regard to mixing Welsh and North Country coal?—Yes; for some years prior to 1887 a mixture of North Country and Welsh coal was used in the Service, but in that year it was entirely discontinued, the Welsh coal having proved of greater efficiency for naval purposes. During the strike in 1898 North Country coal was again used in a mixture with the Welsh coal, but the results were still unsatisfactory. North Country coal is used for yard and boiler purposes. The term North Country coal as used for yard purposes includes Newcastle district coal, Scotch coal, and other coals, for all of which tenders are invited.

12248. (*Sir George Armytage.*) South Yorkshire?—Yes, and South Yorkshire. In determining which was to be selected, price has been the chief consideration, allowing for variation in quality.

12249. (*Chairman.*) Is that because the other conditions are more or less uniform?—They are more or less uniform. Where railway carriage comes in, we find, naturally, that the coal is more costly.

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12250. Well, that depends upon the distance from the coast?—Yes, it does, my Lord; where we can get a coal shipped right away by water it is cheaper than where it has to be carried by rail.

12251. I do not know whether you could answer this question or not: you have once or twice used the words "efficiency for naval purposes." I can understand that expression used in connection with the general conditions, but does "efficiency" also mean calorific efficiency?—Yes. I meant that a coal suitable for naval service would combine all the requirements that I mentioned.

12252. Then it is a fact, is it, that Welsh coal not only has the qualities of being smokeless, hard, clean, free burning, and minimum of ash, but also that for £1 sterling spent in Welsh coal, compared with, let us say, South Yorkshire, Scotch, or Newcastle, you get as much power out of it, do you?—I think it is unquestionable. Welsh coal is the more suited for our boilers, and it is generally understood that it is the more economical.

12253. Have the furnaces to be specially constructed for the burning of the anthracite coal?—Yes, but from such experiments as have been made with anthracite coal it is unlikely that it will prove satisfactory if used alone.

12254. Do you use any of what is called "patent fuel" in mixture with Welsh coal?—We have been making a very large quantity of patent fuel of late.

12255. Is that made from anthracite?—The chief ingredient is Welsh coal, but there is also a proportion of anthracite introduced in the bulk of the patent fuel that we make.

12256. Are those patent fuels made under your own supervision?—Yes, we have an officer appointed to supervise the manufacture and to carry out tests to make certain that the ingredients are of the right description.

12257. How do you secure that you get the quality of the coal, freedom from foreign matter, and so on?—Our patent fuel is manufactured from dock screenings of the coal that we purchase.

12258. Then it really is the small coal out of the coal purchased by you?—Yes, that is so—obtained in the second screening. There is the colliery screening in the first instance, and dock screening during the shipment. The dock screenings are taken to a manufactory with which we have a contract, and they are there mixed with anthracite, and another ingredient. The patent fuel is made under supervision throughout.

12259. Then, supposing you run short of it, do you buy the screenings from the pits?—No, we never buy colliery screenings. On one or two occasions we have bought extra dock screenings.

12260. Dock screenings from other coal than yours?—Yes, but as a rule we double screen, as may be required for making this patent fuel, and obtain sufficient.

12261. What is your experience of this patent fuel? Is it satisfactory in the first place *quâ* fuel?—It is found to be a very good substitute for ordinary Welsh coal. Patent fuel will keep for prolonged periods without showing signs of deteriorating, and is for that reason useful where it is necessary to maintain large reserve stocks, especially in hot climates, where coal would be liable to deterioration by long keeping.

12262. Is patent fuel made into briquettes of any shape which is peculiar or special to them?—Our make is of special size.

12263. Does the furnace require any alteration, or are the briquettes broken up?—No, they are broken up and used in exactly the same way as Welsh coal.

12264. Mixed with it, or separately?—Separately, but they can be used mixed if necessary. They have not hitherto been used mixed with Welsh coal, although in China they have been mixed with Westport coal. We mostly purchase them for reserve stock, but certain quantities are used every year to see that it is in good condition, and also to give stokers experience in the use of them.

12265. Then you are hopeful that anthracite coal made up in that form may be more used for storing abroad?—Yes, but the anthracite bears a comparatively small proportion to Welsh steam coal in the ingredients of the patent fuel.

12266. How long can you keep it in that form?—I think an indefinite period. There was some in South Wales the other day at the factory which had been there for six years exposed to the sun and the weather the whole time; we had three or four of those briquettes tested, and they proved to be in excellent condition.

12267. They showed little sign of deterioration, did they?—Little, if any.

12268. Have you tried any other kind of fuel?—We are at present trying fuel oil.

12269. Does this promise to be serviceable?—At present the use of this oil is in the experimental stage. A prolonged series of preliminary trials has taken place to determine its adaptability for Service purposes, and also to determine the type of furnace best suited for its use. The preliminary trials have proved so satisfactory that an extended trial is arranged for, and is now taking place in seagoing ships.

12270. (*Sir George Armytage.*) That means that furnaces are being adapted for the use of it, I understand?—Yes, they are being adapted for the use of it. Much will depend upon the results of these trials, whether or not it is adopted in the Service.

12271. Whether it will be continued?—Yes.

12272. (*Chairman.*) Are you trying various kinds of oil from different districts?—The oil we are obtaining now is mostly Texas oil. Our supplies at present necessarily come from abroad. We have tried oil from the United States and from Borneo.

12273. Have you tried the Scotch oil?—We have also tested the oil that is manufactured in the Shale Oil Works in Scotland, with good effect. There is also a large source of supply in the Russian oil-field (Astatki) but the cost has been almost prohibitive. I understand that the price is falling. At present we rely mostly on Texas.

12274. What is the relative value of coal and fuel oil?—The experiments that the Admiralty have carried out have led to the conclusion that, approximately, 10 tons of oil are about the equivalent of 13 tons of best Welsh coal. Those are only approximate figures; they may be liable to revision after the extended trials which are going on now have been completed.

12275. Do you know whether any attempt has been made to solidify oil and convert it into a form of briquette?—Attention has been drawn on two or three occasions in the past to a form of briquette that contained a considerable percentage of oil. I have not heard hitherto of any satisfactory solidification of the petroleum, but with regard to those briquettes that were submitted to the Admiralty, it was considered that they were somewhat dangerous on account of the gas which they gave off, and the exudation of oil. In the last few days we have received a communication from a firm in Amsterdam bringing to our notice a solidified form of this oil, and we have asked for particulars.

12276. That is somewhat in the form of a briquette, is it?—We do not know yet. They have simply written to us to say that they were able to solidify oil in this way, and asking us to try it, and we have asked them for particulars.

12277. Has there been any attempt made to combine, for example, peat and oil?—We have never tried that in the Navy.

12278. Have you heard of it?—Yes, I have heard that peat fuel is of considerable value, but I should doubt whether it would be useful for naval purposes.

12279. The sources of supply of oil at present, at all events, so far as you are concerned, are nearly wholly foreign countries?—I have made inquiries in Scotland, and I find they could supply us with a substantial quantity of oil, but nothing, of course, compared with what would be required if oil were universally used in the Navy. There are also coal and blast furnace oils, but they could only be obtained in comparatively small quantities. With these exceptions the sources of supply are foreign.

12280. When you speak of "blast furnace oils," does that mean recovered in some form?—It is a bye-product of the combustion of coal in the blast furnaces during the smelting of iron.

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Mr. Gordon William Miller, C.B.

18 Mar. 1903.

12281. Are you aware of any attempt to extend the production of fuel oil within this country, or have you anything to suggest with regard thereto?—There can be no doubt that a vast quantity of oil bearing shale exists within the country. That has been brought to the notice of the Admiralty on two or three occasions, and especially some length of time ago by Admiral Selwyn.

12282. Does that include Dorsetshire?—That includes Dorsetshire—the Kimmeridge beds; but, with the exception of the Scotch shale fields, it has not, I understand, been found practicable to extract the oils with any approach to financial success, chiefly in view of the competition with the foreign and Scotch oils.

12283. That is a question of price?—That drifts into a question of price. I think one of the points is that, in treating the shale, the position of the coal is a matter of much importance. For instance, in Scotland the coal is close to the shale, but in Dorsetshire either the coal must be carried to the shale, or the other way about, and that would involve great expense. I think it is quite possible that the general adoption of oil in the Service and elsewhere as a fuel would set up a new industry in the production of oil specially suitable for the purpose that might bring about a development of the resources of the oil-bearing shales in the country.

12284. Is it known whether any oil exists in Canada?—There is much uncertainty about the oil in Canada. We have not had any offers of oil from that source as yet, and if oil were worked satisfactorily in Canada I think we should have had offers.

12285. (*Dr. Le Neve Foster.*) It is being worked. They perhaps consume all they produce in the Dominion, and there is none to spare?—I think that possibly may be the reason. But, of course, as the use of oil in the Navy develops we shall receive offers from sources of supply all round.

12286. (*Chairman.*) Do you know whether any oil has been found in Egypt?—I am not aware of that, my Lord. I did hear some time ago that oil had been discovered in Egypt, but no applications have reached the Admiralty.

12287. Or in India?—We know there is some in Burmah. There are considerable oilfields in Borneo which might be used for supplying requirements in the East if oil fuel were adopted. Of course, the Admiralty attach a great deal of importance to adequate supplies being obtainable from within the United Kingdom if oil were adopted in the Service.

12288. I suppose the Admiralty would welcome the extension of the industry?—They would.

12289. And the supply?—Of course, the introduction of oil into the Navy would be gradual. Vast quantities of shale would have to be treated to produce the quantity of oil that would be required for the Service if oil fuel were generally adopted.

12290. Is it known whether the testing of these shales is going on in different parts of the country?—No, I have not heard of anything of the kind going on except to a very small extent, and the Admiralty would be very glad if the testing of shales known to exist in several parts of the country could be encouraged. They think that a system of tests would be of considerable value in solving the question. It is not a matter, perhaps, that the Admiralty themselves should take up. If an extensive oil-producing industry of the kind could be set up, the working of such an industry and the supply of the oil would be a matter, I think, that could be dealt with better by private enterprise rather than by the Government.

12291. Without going into particulars (I do not want you to reveal any of your secrets) could you tell the Commission generally whether you think, with the information at your disposal, there is an increasing supply of coal available outside this country for your purposes?—Outside the country?

12292. Yes. In other words, are the discoveries of coal which are being made everywhere, so far as one can judge, throughout the world—in Australia, New Zealand, Natal, China, Japan, India—we know all those ——? Yes.

12293. Would you say that a supply of coal suitable for naval purposes is being revealed in increasing quantities?—Except the New Zealand coal I do not think we have heard of any coal yet that answers our requirements. Australian coal is used on the Australian station, but it is not so suitable as Welsh and New Zealand coals.

12294. The New Zealand coal is a good coal, is it?—It is very good coal, not quite equal to Welsh.

12295. It is too early to know what China can produce, is it?—We do not know much about China coal. The rule in regard to foreign coal is that wherever any new coals are brought to notice the commanders-in-chief on the different stations report the circumstances to the Admiralty, when investigation follows, as well as trials when circumstances justify them. We had a case the other day of coal reported from the West Indies. Inquiries are being made about it, but I am afraid it is not of much value.

12296. When you say "not of much value," you mean for naval purposes?—Yes.

12297. But, still, they all go to take the place of something else?—Yes. Of course, there are some good descriptions of coal in the United States, but we do not draw upon them to any great extent.

12298. Is there any coal in South America?—I have not heard of any. It is all Welsh coal that is used on that station. It is supplied by local contractors, but the conditions of the contract are that it is to be Welsh coal.

12299. Then what do you say with regard to the Pacific?—In the Pacific some coal has been brought to our notice in British Columbia—that is the only place; but it is not considered to be equal to Welsh, and we are in the habit of sending Welsh coal out there. We burn small quantities of the local coals, because they may improve. We keep in as much touch with local coals as we possibly can. Japanese coals are not suitable for general naval purposes.

12300. What does the Japanese Navy use?—I am unable to say.

12301. (*Sir Lindsay Wood.*) Do you know what your briquettes are made with other than coal?—Merely with pitch.

12302. Does that make much smoke?—There is some smoke, but it is considered to compare satisfactorily with the ordinary Welsh coal.

12303. They make more smoke than Welsh coal, do they not?—Yes, a little more, but manufacturers are endeavouring to reduce the pitch so far as possible in order to minimise the smoke.

12304. Is there any creosote used in that manufacture?—No.

12305. There are other mixtures than pitch with which to make briquettes?—Yes, I think so, but not with ours. We have been obliged to be very careful in the manufacture of our patent fuel, because its use was discontinued in the Navy some years ago, on account of unsatisfactory qualities, and effect on the health of the men. That is not now experienced with this fuel.

12306. (*Chairman.*) In conection with the manufacture of briquettes for you, you told us that they were made for you out of your own coal?—Yes.

12307. And under your own supervision and tests?—Yes.

12308. Do you employ the persons who make those for you? Are they wholly employed in that manufacture?—No, the manufacture is effected by a contractor, but an engineer officer of the Navy looks after those works exclusively.

12309. So that they do not get the coal heaps mixed?—I do not think there is any chance of that.

12310. (*Sir Lindsay Wood.*) You gave us the relative value between coal and oil—that is, 10 to 13, I think you said?—Yes.

12311. Could you give us the difference in price between those two? Do they run much the same per ton?—Up to the present time the cost of the oil has been unfavourable, because we have not been able to enter into any large contracts. We have had to buy the small quantities we have required for the trial purposes, under conditions which probably would not occur if we bought larger quantities.

12312. (*Chairman.*) I suppose the oil would cost about £2 per ton, would it not?—More than that in small quantities. We have been paying 50s. per ton. We have required a higher flash point than that of the

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ordinary oil that is used commercially. It is necessary to proceed very cautiously in dealing with the flash point to ensure safety under the exceptional circumstances of war ships.

12313. A high flash point means high price?—Yes, but better prices may rule should we be in a position to enter into large contracts.

12314. (*Sir Lindsay Wood.*) Do you think the difficulty of cost would be sufficiently overcome to enable oil to compete with the present use of coal?—I could not say that, so many considerations are involved, and the results of the trials must be awaited.

12315. (*Mr. Brace.*) From the experiments that you have tried, what is the likelihood of oil superseding coal?—That is a technical question which I could not very well answer. I think it greatly depends on the outcome of the extended trials in these sea-going ships. They are the first of such extensive character that we have had in the Navy. All these trials are being conducted under the supervision of the Engineer-in-Chief of the Navy.

12316. But for the moment, at any rate, there is not much likelihood of oil superseding coal, unless these experiments prove something more than what you have now?—The results of the trials that have been made to ascertain the suitability of oil as an auxiliary for steam production are considered to be promising.

12317. (*Chairman.*) Can you tell us whether you have any knowledge as to any experiments having been made in America, in the United States?—No, I am not aware of that, but I understand that the reports of trials in the United States are published.

12318. (*Dr. Le Neve Foster.*) Are there not Russian ships using oil?—Yes, some are, but it is difficult to obtain reliable information as to results.

12319. (*Mr. Brace.*) I have made a note with regard to a remark which has been made as to briquettes versus Welsh coal, which you have rather covered, although not quite satisfactorily to me, and I should like to put a further question upon it. The great trouble with briquettes has been, and, as I thought, was now, that they gave off smoke very heavily in consequence of pitch having to be used to the extent necessary to make them bind?—Yes.

12320. In what special way have you been able to overcome that over and above the ordinary manufacturer of briquettes?—I cannot speak on this point from a technical point of view, but our briquettes are made of the smokeless coal that we purchase; the pitch, no doubt, adds something to the smoke; but the reports of the trials have been that smoke has not been excessive. I served on the Committee which dealt with the introduction of patent fuel, and the reports that were received were favourable, both as regards smoke and general efficiency.

12321. I should like to know more about it, really, because the trouble with briquettes has been that they give off so much smoke. There have been a number of experiments made with a view of making briquettes from the coal when it is at boiling point to save the putting in of so much pitch?—Yes.

12322. I know the way in which you consider that the smoke question is of great importance in connection with the manœuvring of the fleet, because if much smoke is given off the fleet can be detected very much more quickly at a greater distance than when smokeless coal is used?—Yes, that is one of the reasons.

12323. It is, no doubt, a great reason. I was turning over in my mind an experience I had when I saw the French fleet manœuvring, when they were using briquettes, and you could see them for miles. With that fact in mind, would it not be rather a serious thing for the Navy to have to depend upon briquettes in the case of war?—The French briquette may possibly not be made of the same ingredients as ours.

12324. Take our own British briquette. In case of war, are you fairly confident that the briquette, which you now speak of, and which is made for you, could satisfactorily replace the best Welsh steam coal?—That is the opinion of the technical officers. One of the main objects in our manufacture of briquettes is to enable us to keep a reserve stock, which does not deteriorate. The patent fuel supplements the reserves of coal, and permits the reserves of coal to be turned over with sufficient frequency to prevent deterioration.

Mr. Gordon William Miller, C.B.
18 Mar. 1903.

12325. Yes; but if that reserve stock is not of that quality (and this is the first time I have yet heard that there has been any kind of briquette made which is within measurable distance of Welsh steam coal), would it not be trusting to much too briquettes?—That is not the opinion of the technical officers. We have to keep stocks at some foreign stations, which remain unused for many months, perhaps more than a year. Welsh coal would deteriorate after long keeping. Patent fuel is a satisfactory substitute, much less liable to deterioration.

12326. I was going to ask you about that; how long will Welsh coal, which is stored, retain its properties?—It is generally assumed that Welsh coal will keep in good condition for a twelvemonth under favourable circumstances. Experiments are about to be made to test the rate of deterioration for different periods at tropical depôts.

12327. I understand it will keep longer than that?—Some places where it is necessary to store Welsh coal are in the tropics, where the climate is trying for coal.

12328. I agree; and that is one of the reasons why Welsh coal is so valuable, because it retains its properties under those circumstances. You say you have used the New Zealand coal?—Yes.

12329. And that is not quite so good as Welsh coal?—The reports are that it is not quite so good as Welsh coal.

12330. I should like to have the information from you, if you can tell me, under what conditions you made the comparison: was the New Zealand coal used fresh, or was it from a stock which was stored, and was the Welsh coal used fresh, or from a stock that was stored?—The reports we have had on the subject have included comparisons between fresh wrought and stored coal in each case; there has also been the general experience of officers conversant with the properties of both coals. I may say that one of the reasons for the use of New Zealand coal is that it is desirable to have a second source of supply for the China station.

12331-2. Yes, I quite follow you, but as to the comparative value of coals, would you place New Zealand coal anywhere near best Welsh steam coal for naval purposes?—New Zealand coal was reported by the engineer officers to be a very good coal; but it is not considered to be quite as good as Welsh coal, although a satisfactory substitute.

12333. No, I think you are right.—It is somewhat inferior, but it is a description of coal which is considered to answer the purposes under the circumstances.

12334. Have you experimented upon, or have you used for naval purposes, any coal from the United States?—The only coal we have had from the United States in large quantities was what we bought five years ago, but we occasionally use it on the North American station.

12335. Would that be when the Welsh strike was on?—Yes.

12336. What class was it—was it Pocahontas?—We bought both New River and Pocahontas.

12337. Will you please tell us what was your experience of that coal?—Yes.

12338. I should like to know, because Pocahontas is supposed to be a fairly good substitute?—The reports received were to the effect that Pocahontas was a fairly good substitute for Welsh coal. New River coal did not prove so useful, but the purchases of that description were small, and we have little experience of its use.

12339. But exactly the same thing applies, that when it is used fresh it is all right, but it will not stand stacking?—We have very little experience of the storage of Pocahontas coal. The only criticism was that it occupied unusual space in stacking, on account of its being so small.

12340. Yes?—The purchase was exceptional, and has not been followed up by further use of this coal, except small quantities on the North American station.

(*Chairman.*) You do not usually praise the coal before making the purchase.

12341. (*Mr. Brace.*) And not after, I am afraid. Clearly the best coal that you know for naval purposes is Welsh steam coal?—Unquestionably. I do not think there can be any doubt upon that point.

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Mr. Gordon William Miller, C.B.

18 Mar. 1903.

12342. I was going to put one general question to you: Welsh best steam coal is being exhausted at an extraordinarily rapid rate?—Yes.

12343. In face of the fact that it is the best known fuel for naval purposes, and also in face of the fact that there is more than a probability of the best seams being exhausted within measurable distance, do you think something ought to be done to reserve a certain portion of the best coal for the Admiralty?—The Admiralty have considered that matter, and they have not seen their way to take any steps in that direction. They consider that a purchase of land property for the purpose would be impracticable, especially in view of the quality of the coal that is required for the Naval Service, and doubt whether, if the Admiralty purchased the land, the required description of coal would be found when a shaft came to be sunk.

12344. I am afraid that all the land is taken up where the best coal is, and there can be no doubt that the best coal is being exhausted, and that the coalfield now has to depend more and more upon its second and its third class seams?—Yes, that is a matter about which the Admiralty is necessarily anxious, but they have not seen their way either to adopt that course or to purchase collieries.

12345. (*Mr. Brace.*) I think this Commission will have to make a recommendation upon this point, will they not, and I was rather anxious to know. Does not that come within the Terms of Reference?

(*Chairman.*) I do not think so.

(*Witness.*) The Admiralty feel that there is so much uncertainty in the result; they might purchase a tract of land, or they might purchase a colliery, and eventually find expectations as to quality or quantity not realised.

(*Mr. Brace.*) I am just seeing whether it is within the Terms of Reference; I should think it is

(*Chairman.*) I do not think there is anything here which enforces upon us the duty of making any recommendation as to whether the Government should buy coalfields, but the duty is put upon us to say what in our opinion is the time within which the supply, especially of the more valuable kinds of coal, will be available for British consumption, including the Royal Navy.

(*Mr. Brace.*) Thank you. That is all I have to ask.

12346. (*Professor Lapworth.*) So far as your experience has gone, you hold that there are no coals anywhere the world over, with the doubtful exception of those of New Zealand, and part of the United States, that are at all equal to the South Wales coal for naval purposes?—I think I may say that is the case; even our briquettes are made of the best Welsh coal.

12347. So that in your view, at any rate, so far as we can gather from the past, the Navy will have to depend for its coal upon South Wales?—That is so.

12348. Next you refer to the possibility of the use of oil in ships of the Royal Navy, and in regard to that question you say that the analyses of the bituminous and the oil-bearing shales had better be left to private enterprise rather than undertaken by the Government?—By the Admiralty.

12349. Well, let us say the "Government" as a whole?—Yes, that is the opinion of the Admiralty.

12350. You are aware, I suppose, that there is a Department under the control of the Government known as the Geological Survey, which has for its object the investigation of the minerals and the mineral resources of the kingdom?—I was under the impression that I had alluded to the development of these shale fields.

12351. I understood it was the analyses and the examination of these shales.

(*Chairman.*) No, it was rather as to the development, that is to say, the development of a shale-oil industry, and tests being made from time to time.

(*Witness.*) Yes, that is what I intended, my Lord.

12352. (*Professor Lapworth.*) But the question I am going to ask, I think, bears upon that. There may have been some misunderstanding.—As far as the analysis is concerned, I think the Admiralty would be only too glad that it should be taken up in any way.

12353. Whether by a Government Department or outside?—Yes. The means of investigation is a matter which the Admiralty can hardly deal with.

12354. Perhaps I might go a little further, so as to get the opinion of the Commission upon the matter. At present the Geological Surveyors are analysing the various coals of South Wales?—Yes.

12355. Generally and for the benefit of the nation. You would not dispute the advisability of their also taking up the bituminous and oil-bearing shales and analysing those in the same way?—Certainly not.

12356. Now would you allow me to go a step further—do you think it would be for the advantage of the Navy and the country that they should extend this investigation to the analysis of the bituminous shales as well as of the coal?—I think it would be to the advantage of the Navy that those investigations should be carried out. Which is the best method of doing it, I can hardly say, but certainly if investigations are being carried out, and they could be sufficiently extended, I should think it would be greatly to the interest of the Service and the public.

12357. We will get that point clear, if you do not mind. At present the analysis of the coal is being carried out by this Government Department, but the development of those coals for the purpose of profit is being carried out by private enterprise?—Yes.

12358. What I want to get from you is whether it would not be advisable to extend these analyses of coal to the analyses of the oil shales, so as to find out what is the value of the oil shales, and then allow the development of those oil shales, for the purpose of making profit, to be left to private enterprise?—Most certainly.

12359. (*Mr. Sopwith.*) With reference to Professor Lapworth's question as to the analyses of oil shales, assuming that the trials with oil in the Navy are successful, would it not be better to have some actual works established for the purpose of trying different oil shales, at the expense of the Government, so as to enable private enterprise to take the matter up; that is, that a practical test of the shales would be of very much greater value than the mere analysis?—Unquestionably. A practical test would include the consideration whether the industry could be worked as a commercial success, but analyses alone might not sufficiently elucidate that.

12360. It need not necessarily be a very expensive matter?—I mention "working as a commercial success" because there are certain bye-products which are of considerable value. A shale may produce a considerable quantity of crude oil and yet may not possess those bye-products which would make it of sufficient commercial value.

12361. Quite so. You think it would be necessary to have some practical tests as well as analyses?—Yes.

12362. And that it might be very difficult to get individuals to put up plant for the oil tests, whereas one establishment might do for practical tests on a large scale for a number of shales?—Yes, but it is very doubtful whether the expense of anything more than analytical tests (such as by the Geological Survey) should be borne by the Government. A central establishment for the practical test of descriptions of shale found in different parts of the country would doubtless be of great advantage, but I would suggest that the expense, which could not be inconsiderable, might be borne by those in whose interests the practical tests might be undertaken. What struck me about the matter was this: some shales are especially valuable on account of their bye-products of solid paraffin, ammonia, etc., which realise considerable sums of money besides the sale of the oils. Taking another shale, the possibility is that it might be deficient those bye-products that would make the working of it profitable; but there is another consideration, I think, that if fuel oil be adopted generally in the Service, and possibly outside, it may set up a new industry, and bring about new methods of obtaining oil suitable for fuel at a reasonable cost, irrespective perhaps of deficiency in bye-products. The suggested practical tests might be of help in this direction.

12363. I think it is very unlikely that there will be very much private endeavour in the way of distilling oil from shales, or making practical tests of the oil shales, unless the trials are satisfactory. Would these trials be made public?—I should think it would be difficult to prevent it if they are trials of shales belonging to different people.

12364. I mean the Admiralty trials in the Navy?—You refer to the trials in seagoing ships?

12365. Those which you have in hand at the present time?—They are treated as confidential, but they will

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be in the direction of determining whether or not the use of fuel oils for naval purposes is possible.

12366. It would rather come to this: The Admiralty would say, "We would probably use a certain amount if we can get oil at a certain price; we have found out that we can use it perfectly well," and this would be opening the door to private enterprise for the development of those shales by any person who thinks he has the proper shales to develop?—Yes; it may be found that a particular class of shale is of value for the production of oil for fuel purposes; if that is established I think several enterprising people who possess such a shale would proceed to develop their property.

12367. I understand that you are making trials at the present time with anthracite, which you may say is at one extreme end, and oil, which is at the other?—We are trying the use of anthracite coal in conjunction with oil in the same furnace.

12368. Then, you are making every endeavour possible to use all sorts of coals and all sorts of combinations in the Navy?—Yes.

12369. That being entirely a question of whether you can construct furnaces which will consume the smoke?—Not entirely. Smokelessness is a most important condition, but there are others which must be fulfilled.

12370. If you can find furnaces which will consume the smoke, and you have a coal which maintains its character, and does not deteriorate, of course it would alter the question about the special and individual value of the Welsh steam coals?—Yes. It is necessary to have furnaces capable of burning Welsh coal, or the best substitutes generally obtainable for marine boilers. The type of furnace is not determined only upon consideration of the kind of fuel to be used; it depends also upon the type of boiler and power to be developed. The furnace fittings, however, can be modified to a certain degree, and are now modified to admit of the use of some kinds of coal other than Welsh. Trials are being made to ascertain if further modifications in these fittings can be made to admit of the use of a greater variety of coals.

12371. It would be a very long time before you could establish any one of these combinations, as you would have to go to the extent of altering the whole of the furnaces throughout the Navy?—Yes, as regards the furnace fittings and their accessories. What we are trying to do is to get coals or mixtures outside the collieries that I named, which, for general purposes, would be as good.

12372. You still look forward to South Wales as the mainstay?—Yes; we have not been able to go outside the South Wales district at present, except New Zealand coal and some local coals.

12373. And you do not think these trials which you are making will seriously alter the position?—That can only be determined by the outcome of trials. One of the aims in view is this: we know there is a vast field of coal of an anthracite character to the north-west of the steam coal district, and we should be glad if we could bring some of those coals of an anthracite character into use with the more bituminous coals from the south-east of the district.

12374. Of course, anthracite coal is used a great deal in America for navigation purposes, is it not?—I am unable to say, but I understand particulars of coal trials in the United States Navy are published.

12375. It is entirely a question of stoking and draught in regard to burning anthracite, is it not?—Yes, but I suppose it is the same with the American Navy as with ours. Wherever ships go they must be able to use coal generally obtainable for marine purposes.

12376. But supposing they had an ample supply of anthracite, there would be no reason that it would not do for marine purposes?—No, provided they could get it wherever they went.

12377. But is it not possible that some smoke-consuming furnace might be arranged which might be suitable for all classes of coal?—I do not think such a thing has been arrived at, other conditions being also fulfilled.

12378. But you are trying to do it?—We are trying to bring about mixtures of coal which will answer the same purpose as the coal from the collieries we are dealing with now, and arrangements of furnace fittings are being tried with the object of adapting them to burning different kinds of coal.

12379. (*Professor Lapworth.*) But if a smoke-preventing furnace were invented—a cheap one—that would alter the whole of these conditions?—It would unquestionably, if all the other requirements of a coal were maintained.

12380. Because you could use almost any coal?—Yes.

12381. (*Chairman.*) There is no Mond gas used, is there?—No, we have not tried that yet.

12382. (*Mr. Maclay.*) Is there any reason, putting aside the question of smoke, why the ships of the Navy should not be treated in the same way as those of the Mercantile Marine?—I think they practically are, except as regards this question of smoke and other important considerations peculiar to the service.

12383. I do not think you will find many ships associated with the Mercantile Marine which use only Welsh coal?—I am certain that if any other coal which was suitable for the Navy existed on any stations abroad or in the British Isles, it would be used—that is, consistently with its being economical in price.

12384. If the owners of the ships in the Mercantile Marine fleet of the country find other coal than Welsh also serviceable, is there any reason why it should not be equally so for the Navy?—There is no reason, if it comes up to our requirements, which I mentioned; if it does not come up to those requirements, then that coal would not be used.

12385. But I do not understand that you have mentioned any requirements besides those of heat and smoke?—There is the calorific efficiency, smokelessness, cleanness, hardness, free burning, minimum of ash and clinker, and that the coals will not cake or give trouble in stoking. Those are the leading points.

12386. Yes, that is so, but do you not think the owners of the Mercantile Marine take those matters into consideration?—I do not think they do wholly.

12387. Do you not think private individuals are likely to look closely into such matters?—I do not think they mind smoke, for instance.

12388. Is there any reason to mind smoke except in times of war?—The coal used in peace must be of the same description as that used in war, so that ships may at all times be ready for emergencies.

12389. But you put a great deal of stress upon this question of smoke. Is it not the fact that, in time of war vessels may have to use any kind of coal they can get?—Yes, possibly when reduced to extremities; but otherwise we should supply them with coal from this country. Arrangements are made to supply the English Navy with Welsh coal, even in time of war—where we can get it to them, except when suitable local coal is obtainable.

12390. But except in time of war, does the question of smoke arise?—The ships of the fleet have always to be ready for war, and they must consequently be coaled up with coal that can be used in time of war; and manœuvres are carried out under the same conditions as in war. I do not think the Admiralty would consider it expedient to use in time of peace a particular kind of coal which could not be used in time of war, otherwise we should require to have a stock of coal at various places to be used in time of peace, and another stock to be used in time of war. Moreover, smoke impedes signalling, and is consequently very undesirable in movements of fleets.

12391. The point I wish to bring out is this—whether the Admiralty should not look at matters more from a commercial standpoint than they are doing at present. I quite admit what you have been doing in the past, but from my point of view it is rather this—that the Government have been taking rather too restrictive a view with regard to the position of Welsh coal?—I am afraid it would be impossible to move the Admiralty on that point, unless a satisfactory substitute could be found.

12392. What I suggest is that the coal which is suitable for the Mercantile Marine is also suitable for the Navy?—But I think the principal lines of the Mercantile Marine enter into large contracts for South Wales coal.

12393. Only for certain places.—A ship of war must be supplied, and must be kept supplied, with a coal

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Mr. Gordon William Miller, C.B.

18 Mar. 1903.

that will ensure the highest rate of speed and maintain the required radius of action. If you use a coal that burns quicker, without producing the same calorific effects and power, you would burn out the coal sooner than you otherwise would, and the consequence would be that a ship instead of running her 10,000 knots at a certain speed, would be reduced probably to 8,000 or 9,000 knots.

12394. Yes, of course, it is a matter of consumption. You would burn a little more of the other coal than you do of the Welsh coal?—Yes.

12395. That is the way in which the Mercantile Marine look at it, and it is only natural; it comes out cheaper.—Assuming that all our ships are kept ready for war, ready for any emergency, and ready to be ordered anywhere at short notice, they must be filled up with the best known quality of coal for steam raising purposes which will ensure the required speed, and also the maximum radius of action.

12396. Is it not the case that firemen are prejudiced very much in favour of Welsh coal?—I do not think they have much option.

12397. And the engineers?—I do not think that prejudice would have any influence at all with them.

12398. Well, it has a great deal of influence in the Mercantile Marine, and engineers and firemen are both prejudiced in favour of the coal which they are in the habit of using?—We do all we can to counteract that, if there is any such feeling; and when we arrive at the stage that we think a coal may be useful to the Service, it is generally tried in several ships, so that a variety of reports is obtained.

12399. Do you not think it is rather to the detriment of the Navy that they do not try a greater variety of coals, in view of the fact that in time of war they might require to use foreign coal very freely?—We do not think that in time of war they would require to use foreign coal very freely. Every effort would be made to keep the fleet supplied with Welsh coal. The properties of any foreign coal that might be useful for Naval purposes in time of war are known.

12400. You say you have tried north country coal in times of strike?—Yes.

12401. But I suppose you do not consider that is a fair time to give a trial to a coal?—No; but the north country coal has been tried over and over again. We have tried Scotch coal and coal from the Newcastle districts, and we have tried all those without satisfactory results, so far as the fleet is concerned. The chief point is the smoke.

12402. The chief point is the smoke?—One of the chief points is the smoke. Speaking generally, Welsh coal has a greater effect than north country coal in our modern boilers at high powers, and is less liable to injure them.

12403. Can you tell us what proportion of the 1,000,000 tons of coal used by the fleet is loaded direct into the fleet in this country?—From the collieries straight away into the fleet, and not into stock?

12404. I want to distinguish between what goes into the fleet in this country and what is sent abroad?—Coal is frequently sent to fleets direct from South Wales ports.

12405. I want to distinguish between the two—I mean between the coals that are loaded direct into the fleet in this country and coals that are shipped abroad for transference to the fleet abroad?—In this country, except during manœuvres, ships largely coal at the naval establishments.

12406. Yes; but I want to get the quantity shipped abroad and the quantity you take here?—I will endeavour to get you that information. I could not give it off-hand.

(*Chairman.*) I think Mr. Maclay's point is this: He wishes you, if you can, to tell him practically what proportion of the 1,000,000 tons of coal is transported. He wishes to determine, as I understand it, how much of the 1,000,000 tons is carried by other ships than the ships of the Navy to the port, whatever it is.

(*Mr. Maclay.*) My point is this, my Lord: I want to get at the quantity of coal taken by the fleet from this country.

(*Chairman.*) Direct?

(*Mr. Maclay.*) Direct.

(*Chairman.*) That is to say, without any intervening means of transport?

(*Mr. Maclay.*) Yes. Then I wish to get at the quantity of coal that is shipped abroad for transference to the fleet abroad, for the use of the fleet abroad.

(*Chairman.*) Well, that would be the balance, would it not?

(*Mr. Maclay.*) That would be the balance.

(*Chairman.*) The only point upon which I see any difference between you is this: There are really three separate portions. First, there is the coal which is taken direct into the ships of the Navy; secondly, there is the coal which is taken by transport from the port of shipment to the port where it is stored, to the dockyards, or what not.

(*Mr. Maclay.*) Not to the dockyards, but abroad.

12407. (*Chairman.*) But surely we have quantities of coal in this country other than at the ports. Is that not so?—Yes.

12408. I mean, supposing you wanted to load a ship, for example, at Portsmouth or Plymouth, or elsewhere, you must have a supply of coal there?—Yes.

12409. Which has been taken from the colliery to that port by some other ship?—Yes.

(*Mr. Maclay.*) But I want to include that in the first position; that is to say, as part of the coal that is supplied in this country.

(*Chairman.*) Therefore, the point is, can you furnish us with information as to how much of the total of 1,000,000 tons of coal which you take for naval purposes is conveyed by transport other than naval transport to coaling stations abroad, plus, I suppose, that transferred direct to the ships abroad. Supposing that a cargo were sent out, and instead of being landed, were transferred from the collier to the ship, say at Gibraltar—you would include that?

(*Mr. Maclay.*) Yes.

(*Witness.*) May I explain that we have three systems of coaling. One is where we coal straight away into the ship from a collier sent from Cardiff or a South Wales port.

12410. (*Chairman.*) That means that really no coal is shipped, let us say, from Cardiff or Newport direct into the man-of-war?—No, never.

12411. Therefore, it is all by collier in the sense you mean?—Yes. We either send coal from South Wales ports to naval establishments or to ships direct. For instance, the fleet may be manœuvring in the Mediterranean, and may require coaling at Corfu. The Commander-in-Chief would make arrangements with the Admiralty to send out colliers to coal his fleet there; that is one method of coaling.

(*Chairman.*) I understand Mr. Maclay wishes you really to separate the coal into two parts: (1) The coal which, as you say, is sent by the collier direct to any home station here, and (2) the coal which is sent abroad, whether it is delivered direct into the ship, or whether it is landed at any foreign station.

12412. (*Mr. Maclay.*) I think, perhaps, Mr. Miller, the better way to do it would be as you indicated a moment ago. Would you give us a return showing what proportion of the 1,000,000 tons goes direct by collier into the ship?—Yes.

12413. And then the balance is what is taken to foreign stations by outside tonnage?—Yes; but there are other systems. We have one system of coaling direct by collier, when the coal leaves Cardiff or South Wales ports, and goes direct to the ship; the second system is, we send coal from South Wales ports to a naval establishment, from which the ships are coaled as may be required, and the third is a system of contracting with private firms, by which they supply the ships at certain ports abroad other than naval establishments.

See Page 155.

12414–16. I want to know what you send direct to the ships?—I am afraid I could not give it to you without looking into details.

12417. The real point I want to get at is this: the great bulk of the mercantile marine take such local or other coals as they can get wherever they happen to be, and I want to know why, apart from this smoke feature,

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the Government should not do the same with regard to their ships of war?

12418. (*Chairman.*) Yes, it is mainly the smoke question, is it not?—It is, mainly; but, as I pointed out just now, we are aware of no local coal at foreign ports that is suitable for our men-of-war, other than coal that I have mentioned.

12419. I understand there are two points, really—one is the smoke question, which is a material one, and the second one as to whether; apart from the question of smoke, £1 worth of Welsh coal will not give as much power as £1 worth, let us say, of Scotch coal?—I do not think that is always the case; take, for instance, the other side of America—British Columbia—we can get coal there at a reasonable price, whereas Welsh coal costs a great deal more money out there; but the local coal is not so suitable for naval purposes.

12420. It is not suitable in the sense that it has not power enough in it?—It has not power enough in it.

12421. Then that comes back to what I say, does it not?—Yes, it does.

12422. I mean if you have a minimum requirement *qud* speed or power, whichever unit you adopt, and if Welsh coal, expressed in money and not in tons, furnishes that minimum better than any other, then, apart from the smokelessness, there is that question?—Irrespective of the expense, we could not go below the minimum standard of requirements special to the Naval Service.

12423. (*Mr. Maclay.*) Why not?—Because the minimum is expressed by the properties of the Welsh coal.

12424. (*Chairman.*) But then, as I understand Mr. Maclay, this is in his mind: never mind the figures being inaccurate, but if you can get out of 30cwt. of Scotch coal (I say Scotch, but you might say South Yorkshire if you like) within the same period of time the same number of miles that you can get out of a ton of Welsh coal, then the question of price may be a very important factor?—The question of price may be a very important factor, were it not for the other consideration, that I should have to burn 30cwt. of coal "A" while I am only burning a ton of coal "B."

12425. And therefore the period of time for which you were coaled would be so much less?—Yes, that is right.

12426. But still there is a point at which that is unimportant?—That is not considered so in the Service.

12427. (*Mr. Maclay.*) Of course, my point is simply this, that I fail to see why the Admiralty should not look more at matters in the same spirit as the Mercantile Marine does. Then one or two further questions: the coal which you take at Cardiff is large coal?—It is colliery screened.

12428. It is what is called large coal; you do not take small?—No, it is colliery screened.

12429. Do you find that contrasted with, say, 1892, you are getting a better horse-power compared with consumption?—I could not answer that question.

12430. Then do you know how the price of patent fuel compares with the price of the best Welsh coals now?—The patent fuel as we make it costs somewhat more than Welsh coal.

12431. Do you know how much?—About 2s. 6d. per ton more.

12432. Do you know how the consumption compares with it?—No, I do not.

12433. Is there any difference in the construction of the furnaces of the ships of war as compared with the furnaces of the ships of the Mercantile Marine?—There is no material difference in form with boilers of the same type, but higher rate of power is developed in Naval boilers than in those of the Mercantile Marine.

12434-5. If you have the furnaces constructed for the use of oil, could they be used in the same condition for coal?—The result of experiments up to the present time is that better results are obtainable from oil by itself, but in the trials now in progress on seagoing ships some of the furnaces are constructed to burn coal and oil together or separately.

12436. (*Mr. Young.*) There is one point I should like to ask you a question upon: you spoke of the experiments made prior to 1887, when it was decided to use practically exclusively Welsh coal?—Yes.

12437. Those experiments commenced in 1873 or 1874, did they not?—Yes, I think it was then. Perhaps you may recollect it was the result of some trials that took place in Newcastle.

12438. Yes, and they were carried on right up to 1887, with certain intervals?—Yes, the use of the mixture was continued until 1887.

12439. There had been some difficulty, obviously, in determining whether Welsh coal was very much superior, everything considered, to the coal that you used prior to that?—Up to that time I should think that such was the case. It was a mixture, mostly, I think, of two-thirds Welsh and one-third north country coal. In some cases it was half and half, but mostly two-thirds and one-third.

12440. Yes, I think that was so. The price of Newcastle coal at that time, in 1873 and 1874, compared with Welsh coal, was higher rather than lower. Was not that so?—I could not say. It is rather beyond my recollection.

12441. I think you at that time constructed special furnaces for mixing the coal?—I am not sure. You mean there were special furnaces used for the mixed coal?

12442. Yes.—Special furnaces were not used for the mixtures of Welsh and north country coal burnt prior to 1887, but there was a special arrangement for admitting air at the back of the furnace, which was used when the mixture was burnt.

12443. Was the question of smoke almost the only factor that was then under consideration, and was it considered that in that respect there was an advantage in Welsh coal over north country coal?—That was one of the principal considerations, but evaporative efficiency was also taken into account. The relative efficiency of the mixture and the Welsh coal was considered to be in favour of the Welsh.

12444. You are now, I believe, making some experiments with north country coal and Welsh coal in mixing? Not with north country coal and Welsh coal mixed. The experiments are with the north country only, and with mixtures of Welsh coals.

12445. Are you trying these experiments in the ordinary furnaces, or are you constructing special furnaces?—The furnace fittings are being variously modified in the case of the north country coal.

12446. You are making experiments with fuel oil?—Yes, on two ships at present, and a third ship will follow.

12447. You have not, I think, quite sufficient oil in this country, so far, to enable you to rely upon that?—Not by a very long way, if oil were generally used in the Service.

12448. Do you think it likely that the Admiralty would change the form of fuel from what is now being used to oil fuel, unless they could have a guarantee that they would have sufficient oil in this country?—That would be a consideration; but, of course, it is possible to get oil from America and elsewhere to any extent.

12449. Only it is not so material as I at first thought, after your answer to Mr. Maclay, because you said you were of opinion that either coal or oil could be used in the same furnace?—The trials in the sea-going ships extend to the use of oil and coal in the same furnace.

12450. That is a matter to be determined?—Yes.

12451. (*Dr. Le Neve Foster.*) Have you any specification as regards allowable quantity of ash, and the necessary calorific power for the coal that you take, or do you rely solely upon practical tests?—There is no specification of that description. We rely upon practical tests, which are conducted under the Engineer-in-Chief, and I merely carry into effect his recommendations as to the coal to be purchased.

12452. Then if anybody said they had a coal with a minimum amount of ash, and of high calorific power, you would take no regard to that?—As a rule the procedure is this: if any colliery proprietor possesses a coal which he thinks would be useful to the Navy, he writes to that effect, and we take a truck load. He sends a truck load to Portsmouth, and that goes through certain tests in a boiler which is kept for the purpose; the several points are observed and noted; the amount of smoke, rapidity with which a certain quantity of water can be evaporated, ash, clinker, etc. Those cir-

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Mr. Gordon William Miller, C.B.

18 Mar. 1903.

cumstances are reported to the Engineer-in-Chief, who considers whether it is desirable to carry out further experiments.

12453. You base your purchase, or the putting of a certain colliery upon your list, upon a practical test with one truck load of coal?—Yes—begun in that way.

12454. (*Chairman.*) No, not with one truck load of coal, as I understand; I thought you said at an earlier stage that the one truck load is the first stage?—Yes, that is the first step.

12455. It is the first step towards getting on the list? but you do not put a man's colliery on the list, as I understand, until after an extended trial?—No; that is the first stage of the trial as to suitability for naval purposes. Then it is usually tried in land boilers, and then in a ship, and if reports were favourable it would be tried in several ships.

12456. (*Dr. Le Neve Foster.*) Would you make any tests with regard to deterioration or with regard to its standing and being stocked for a time?—That would be a part; we might put a coal on the list, and if afterwards it proved unable to stand stacking, or developed any other defect, it would be removed from the list. But I may say that before we take any extended action in the case of a trial, we get reports from our engineer inspector, who makes inquiries generally about the coal—experience in the Merchant Service, etc.

12457. (*Chairman.*) Do you happen to know whether there is any laboratory test which at all indicates or coincides with the behaviour of coal during the period of stacking?—There is no laboratory test. The engineer inspector at Cardiff tests by incineration for ascertaining the amount of ash, etc.; but beyond that we have no analytical test.

12458. (*Dr. Le Neve Foster.*) You said one of the principal qualifications of the coal was that it should be one which gives no trouble in stoking?—Yes, it should give little trouble in stoking; that is a requirement which the Engineering department make.

12459. That point, that there should be no trouble in stoking, and the smokelessness, are the two important things?—Yes, two of the important conditions.

12460. With regard to ascertaining whether there is no trouble in stoking, have you not to depend almost exclusively upon the word of the firemen?—No, there is usually an engineer officer on duty, and it would come under general observation. At the later stages when we are putting, perhaps, 500 or 600 tons on board a ship for trial, the test would consequently be extended before a report was made. Then when we come to a further stage we should probably distribute a larger quantity over five or six ships, thus giving a still further extension of the detailed trial. So I think the reports are beyond the mere opinion of stokers.

12461. But do you not think that if all the stokers are complaining to the officer that would have some effect upon him?—Yes, but only to induce him to investigate the matter.

12462. Do you know how the test with regard to smokelessness is carried out?—It begins, as I mentioned, at Portsmouth in a local boiler.

12463. How is it afterwards carried out?—The smoke emitted from the funnels is watched.

12464. By the person making the test?—Yes, by the ship's officers.

12465. Is it not possible—I do not say commercially—to burn all coal smokelessly; is it not a question of combustion?—Yes, at low rates of combustion, but the difficulty is to burn it smokelessly at high rates.

12466. As regards ash, you have no minimum limit laid down in your specification?—We have not.

12467. With regard to calorific power is there any minimum calorific power laid down?—No minimum is laid down, but this point is always taken into account.

12468. You have told us that a mixture of anthracite and oil is being tried?—It is in contemplation, not yet commenced.

12469. Have any experiments been made for using coal dust fuel?—No, I have not heard of any. You mean injected?

12470. Yes, blown into the furnace?—No, I have not heard of any: in fact, I think I may say that, so far as the Admiralty are concerned, such experiments have never been made in the fleet.

12471. Is not one advantage of patent fuel the fact that you can stow away a larger quantity in the bunkers than you can of ordinary coal; in a given cubic space you could put more tons of patent fuel?—If it were built up in the bunkers that would be the case.

12472. How is it generally stowed in the bunkers—built up or thrown in?—Patent fuel is not built up in the bunkers, but broken, and thrown in. If built up it would take up somewhat less room, but it is not practicable.

12473. Then that would make a difference?—Yes.

(*Chairman.*) It does make a difference in stowing it abroad.

12474. (*Dr. Le Neve Foster.*) Yes, it would make a considerable difference whether they simply threw it in or stacked it up regularly. With reference to the fuel oil which you are using, is it the crude oil as it comes from the wells, or is it the residue after certain portions have been distilled off?—It is a residue after extracting illuminant oils, etc.

12475. Then in all cases which you are speaking of, it is a residue?—Yes. The lighter products must be distilled off to get the high flash point.

12476. Yes, the benzine, and so on?—Yes.

12477. With reference to the oil, is it not the fact that cost should not be the only thing to be taken into consideration. In other words, have you not considerable advantages in the case of oil which are worth paying for?—Yes.

12478. Such, for instance, as cleanliness and fewer stokers?—Yes.

12479. There is a considerably reduced cost with regard to stoking, is there not?—Unquestionably.

12480. Would you not be able possibly to reduce the number of stokers employed by 60 per cent. if you use oil?—I could not say the reduction there would be on a man-of-war, but it is an important factor in considering whether oil can be economically used versus coal.

12481. (*Chairman.*) But you did not take that into account when you gave us the relative proportions of 10 to 13?—No, that was a question of effect.

12482. A question of value?—Yes, as a fuel.

12483. (*Dr. Le Neve Foster.*) That is a point which I had in my mind, that, although you might be paying £3 more for your fuel, you might be saving the excess in cost by diminished bunker space and by diminished expenditure for stokers?—Yes; that is a very important consideration, but we have not had sufficient experience in that direction, up to the present time, to determine the point.

12484. But is not that a point which should be hammered into the heads of people?—Those points have been considered by the Admiralty in connection with this question.

12485. Is not the filling of bunkers with oil more rapid than loading with coal?—I cannot speak with any certainty on that point.

12486. Do you, from what you know, anticipate a gradual replacement of coal by oil?—It is thought that such may be the case, but much must depend upon the outcome of the experiments that are being conducted.

12487. Yes, certainly.—Judging from what one hears elsewhere, it would seem that the oil fuel is likely to come into general use at least as an auxiliary.

12488. You think that is really a thing one may expect?—Yes; it has evidently come to stop. It is more difficult to burn oil on a ship of war than in the Mercantile Marine, on account of the greater power to be developed.

12489. You have told us about coal in the West Indies. May I ask what island that is in?—It is in Trinidad.

12490. What is the harmful effect upon the stokers of using briquettes?—It is not experienced with the briquettes we are using at the present time. The briquettes we used some years ago affected their health.

12491. It is a point which is new to me, and that is why I was asking for information?—I think it was owing to the presence of some substance in the briquettes which were used some years ago.

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12492. Then, to go to another point, with reference to your proposal that the Government should test shales in different parts of the kingdom——?—No; my proposal was that the shales should be tested.

12493. I will put it in this way: With reference to your proposal that shales should be tested, could you fairly expect the Government to make a lot of tests of shale on properties in which they had no interest?—As owner?

12494. Supposing I were the happy owner of shale land which I did not know to be valuable?—Well, I think you ought to be encouraged.

12495. I am not, unfortunately; but, if I were, ought I to expect the Government to do the work for me when the Government itself would get no benefit, not being the mineral owner?—What I think is this: I do not know exactly how it can be done, but I think the owners of beds which are supposed to contain oils should be encouraged in some way to have them tested; it is to the public interest that some organised system of test should be established.

12496. Do you not think that a man who is the owner of a shale property would say to himself, "If I can make any money out of my property I will"?—Yes.

12497. Would he not go to a chemist or some expert and get these matters tested for himself?—Yes. What I think is this, that if a new industry is set up by the general use of oil as a fuel, and if this oil can be produced from oil shales profitably, I think very many people would, of their own initiative, do all they possibly could to find out whether they had such valuable property in their possession.

12498. But is it not more important to get people to do the thing on their own initiative than to wait for the Government to do a thing for them?—I think so. It seems to be important that some means should be devised of bringing about a testing of these shales which exist in the country.

12499. Would you like the attention of owners of shale properties to be called to the fact of the possibility of large quantities of oil being required later on, and to the desirability of seeing whether their properties could not be developed?—Yes; in the public interest, I think that is advisable.

12500. Is not the main requirement of the Navy at the present time the invention of a furnace which will burn all kinds of coal smokelessly, and which could be used alternatively for coal and oil fuel?—I think that is the thing to be desired, but scarcely to be hoped for, in view of all the conditions required in the Naval Service.

12501. Is not that the point to be aimed at—to get inventors to try and produce it?—I should think that must be so, but possibly this problem has been considered. The experiments in progress are in this direction.

(*Mr. Sopwith.*) May I make a remark with regard to Professor Foster's question. I made a suggestion about having some works erected for trials on a large scale, but what I meant was, rather, that they might be erected, and they would do for any amount of shales; and, if it became a matter of such importance to try and find out whether there was likely to be a sufficient quantity of oil obtained in the country itself, that then individuals who owned shales might send them up to be tested, very much in the same way as they make Admiralty tests for coal—that there should be one establishment.

(*Dr. Le Neve Foster.*) Yes; quite so.

12502. (*Mr. Sopwith.*) I never for one moment thought that the Government would come and put works up for private individuals, whoever liked to ask. It would be a long time before they could get that done?—There is another matter which I should mention; possibly oil exists in this country.

12503. (*Dr. Le Neve Foster.*) Yes.—No investigation of any kind in that direction has, I think, ever been attempted.

12504. Well, they are thinking of it in Sussex?—I know that is so. I was there the other day.

12505. (*Sir George Armytage.*) In part of your evidence you gave us some rather startling figures of the great increase of coal that is required year after year by the Navy. The quantity required has more than doubled itself in about 10 years, has it not?—Yes.

12506. May I ask, are thos figures which you gave us inclusive of coal which is bought for stocking and stacking purposes?—Yes, they are. There has been a gradual increase in stock.

Mr. Gordon William Miller, C.B.

18 Mar. 1903.

12507. Those figures do not represent absolutely the current expenditure?—No. If I may be permitted to do so, I will arrange the figures in the return to be prepared in a way which will bring that out.

12508. Then you will be able to give us the actual expenditure of coal in past years and the expenditure at the present time?—Yes; I may say, as fleets increase and the consumption increases the drawing upon South Wales also increases, because the stock is gradually increased in proportion to the consumption.

12509. You see that is particularly noticeable in the last year?—Yes.

12510. You speak of 1,000,000 tons for 1902-3, and you speak of 1,250,000 tons for 1903-4?—Yes.

12511. There is an increase of 25 per cent. in one year?—Yes.

12512. Whereas I do not think you have an increase of 25 per cent. in your ships?—No, but more extended movements of ships are provided for.

12513. Would you be able to tabulate that for us and show us readily the consumption each year, and the amount which goes for stock?—Yes, I will do so.

See Page 155.

12514. (*Chairman.*) As I understand, what Sir George Armytage would like to obtain, and which would be very useful information, is, if you can tell us, what the actual consumption is?—Yes, I can give you that.

12515. (*Sir George Armytage.*) I do not care so much for that, but there must be a balance between the two?—Yes, certainly. There would be no difficulty whatever in dividing these figures. I can draw it up in the one return, which will give all the information that you are asking for.

12516. You have told us that the South Wales district produces, in round figures, about 30,000,000 tons of coal per annum?—Yes, so far as we have been able to find out.

12517. The Navy, practically, takes one-thirtieth of it?—That is so.

(*Chairman.*) One-thirtieth of the whole, and one-thirteenth of the produce of the collieries with which they contract which are the collieries so far as they know, which produce a suitable coal.

12518. (*Sir George Armytage.*) That is so; it is one-thirteenth of the output of those you contract with?—Yes.

12519. What is the method of getting this coal from the collieries to the ships?—The collieries contract to deliver the coal free on board colliers at South Wales ports.

12520. Are those colliers chartered, or do they belong to the nation?—They are chartered mostly. There is one small vessel which belongs to the nation, and there are four which are hired by the year, and one for three years.

12521. If those vessels belong to the nation when they are carrying that coal from the port to wherever it is going to be used, do they use the South Wales coal for steaming?—They would use the same description of coal as the cargo.

12522. (*Chairman.*) But that is not necessary, is it, *qud* smoke purposes?—No, that is merely for convenience.

12523. (*Sir George Armytage.*) It is simply owing to the fact that the coal is there on board?—Yes.

12524. It would be more economical if they were to use something that was not so expensive, would it not?—I may say that vessels taken up for long distance freight (to China, for instance) make their own arrangements with regard to the coal to be used on the voyage. They are not allowed to touch our coal.

12525. That means to say that if you are sending out a ship with coal to China, they make their own arrangements about their bunker coal?—Yes.

12526. Because you send that out by contract?—Yes, we hire the freight. The freight is engaged by our agents in South Wales.

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Mr. Gordon William Miller, C.B.

18 Mar. 1903.

12527. If a man-of-war is sent out to China on her station, does she burn Welsh coal the whole way?—Yes, the whole way.

12528. Although she may be on a voyage, with no prospect of enemies, or war, or anything of that kind?—That may be so, but it may happen that a ship, even on a voyage to China, may be ordered elsewhere. The principle throughout is to maintain a ship always ready for anything—for any emergency

12529. Will you tell me if you have any knowledge as to whether, when your coal is stored in foreign countries or elsewhere, the various climates have any different effect with regard to deterioration of it or not?—Yes; speaking generally, we think they have. Coal in the tropics deteriorates more rapidly than it would in colder climates.

12530. When you say it deteriorates, I suppose it crumbles, does it?—It crumbles, and loses its calorific value.

12531. It gives less heat per ton?—Yes, it reduces the calorific effects. I may mention, as an illustration, that some time ago there was certain coal abroad which it was reported had deteriorated to the extent of about 30 per cent. It had been in stock for an unusual length of time.

12532. As regards patent fuel, does that deteriorate differently?—No; our experience is that it does not, and that patent fuel in four or five years' time is amost as good as when it was made.

12533. The pitch does not melt, I suppose?—No, it does not. We have a large quantity of it in Hong Kong, and it seems to keep satisfactorily there.

12534. We have heard that a large quantity of this coal, when it comes from the collieries, and when it gets to Portsmouth and other places, and has to be put into the ship, has to be a good deal broken up, in order to get it into the holes through which it is put into the ship. Do you know whether that is the case?—I have not heard any complaints of that description, except one. But, of course, a ship of war is really a compromise of everything. The best possible arrangements are made to facilitate the loading of the coal, but the position of the bunkers may be such that it is quite possible that very large pieces of coal cannot be passed down. The large knobs in a cargo are inconsiderable.

12535. Of course, you pay the highest price for the biggest coal?—We purchase colliery screened coal. Some pieces of coal may be too large to pass down into the bunkers under certain circumstances.

12536. That is what I mean—that it has to be broken then?—Yes, necessarily. But anyhow, unusually large pieces would have to be broken before going into the furnaces.

12537. But could you not get a coal sufficiently large which at the same time would not cost you quite so much?—No, I think not.

12538. (*Chairman.*) You made an observation with regard to using the older coal first, and you said that that was your rule?—Yes.

12539. Do you really mean that?—Yes; for instance, we may have, say, a stock of 40,000 tons in a place, which would represent a year's consumption. We always supply the older coal first; otherwise we should accumulate stock that would be deteriorating more than would be necessary.

12540. That is not what I meant. On a railway, with which I have a distant connection, we put down coal as a reserve in case of disturbance or accident in the supply?—Yes.

12541. And we do as you say; we take up the oldest coal first?—Yes.

12542. But we never think of going to the cost of using the older coal first in the sense of putting it all down and having to pick it all up; we consider that there is a waste in that, not only in the cost of putting it down and picking it up, but also in the deterioration of the coal?—Yes.

12543. Therefore, we keep that stacked coal practically as an insurance and as a reserve?—Yes.

12544. But we use as far as it is possible, all current supplies fresh. Is not that possible in the Navy?—I do not think that would answer with the Welsh coal. I notice several stacks on the railways, and I think they are an inland coal and North Country Coal, which is not so liable to deteriorate as Welsh coal.

12545. On the contrary, we use Welsh coal also, and, as a matter of fact, we think Welsh coal deteriorates more than the other by keeping; I mean relatively to its cost?—Yes.

12546. But you have told us that you do coal direct from the colliers into the ships?—Yes, when circumstances permit.

12547. That was my point; to the extent that you can do that, you save the cost of putting it down and picking it up; but, what is far more important, you save the deterioration, because the coal is worth more?—Yes; coal is better when supplied direct from the colliery, but we are obliged to turn over our stocks; we must do that, otherwise we should have coal deteriorating by age.

12548. I quite understand that?—So far as we possibly can, we coal from the collier direct, but we have such large stocks that the principal requirements are drawn from stock.

12549. In answer to Mr. Maclay, you seemed to doubt whether the Admiralty would be disposed to entertain any question of using even a portion of other coal than Welsh on board men-of-war, even in time of peace, and, so far as you can judge, with safety?—Yes. I think that, unless there are very strong reasons for such a course, the Admiralty would prefer to maintain their present system.

12550. Would you agree with this view, that if you could reduce your consumption of Welsh coal 25 per cent. it would put you in a position to buy much cheaper?—We might possibly buy cheaper, but I doubt whether the general effect would result in economy; in the second place, if we reduced our consumption of Welsh coal 25 per cent., it would only be a small reduction on the total output from these collieries.

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APPROXIMATE PARTICULARS OF COAL PURCHASED FOR H.M. SHIPS.

Financial Year.	British Coal.			Colonial and Foreign Coals.		
	Actual Consumption by H.M. Ships.	Additions to (+) or Reductions in (−) Stocks.	Total.	Actual Consumption by H.M. Ships.	Additions to (+) Stocks.	Total.
	Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*
1891–2	390,000	—	390,000	23,000	—	23,000
1892–3	367,000	− 8,000	359,000	20,000	—	20,000
1893–4	434,000	+ 23,000	457,000	20,000	—	20,000
1894–5	446,000	+ 40,000	486,000	25,000	—	25,000
1895–6	475,000	8,000	467,000	27,000	—	27,000
1896–7	581,000	+ 62,000	643,000	24,000	—	24,000
1897–8	692,000	− 24,000	668,000	34,000	—	34,000
1898–9	683,000	− 1,000	682,000	28,000	—	28,000
1899–00	760,700	+110,000	870,700	29,000	—	29,000
1900–1	832,600	+ 45,000	877,600	43,000	+ 6,000	49,000
	—	+ * *10,960*	* *10,960*			
1901–2	879,500	− 53,000	826,500	74,000	+ 8,000	82,000
	—	+ * *51,294*	* *51,294*			
1902–3 (estimated)	940,600	+ 14,000	954,600	87,000	+ 23,000	110,000
	—	+ * *33,646*	* *33,646*			
1903–4	1,117,000	—	1,117,000	122,000	—	122,000
			* Patent Fuel.			

The following approximate quantities were supplied direct from colliers to H.M. Ships:—

1901–2	300,000	included in totals given above.
1902–3	300,000	
1903–4	350,000	

List of the Twenty-four Descriptions of South Wales Coals Supplied to H. M. Ships.

1. Albion Merthyr.
2. Cambrian Navigation,
3. Cory's Merthyr.
4. Cyfarthfa.
5. Dowlais Cardiff.
6. Dowlais Merthyr.
7. Ferndale.
8. Great Western Navigation.
9. Harris's Deep Navigation.
10. Hill's Plymouth Merthyr.
11. Hood's Merthyr.
12. Imperial Navigation.
13. Insole's Merthyr.
14. Lewis Merthyr.
15. Locket's Merthyr.
16. National Merthyr.
17. Naval Merthyr.
18. Nixon's Navigation.
19. Ocean Merthyr.
20. Oriental Merthyr.
21. Penrikyber.
22. Powell Duffryn.
23. Standard Merthyr,
24. Ynysfaio Merthyr.

Note.—In addition to the above two other Collieries are on the list for limited supplies though Contractors at Ports abroad, viz., Maclaren Merthyr, and Rhymney.

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Sir GEORGE LIVESEY, called; and Examined.

Sir George Livesey.

18 Mar. 1903.

12551. (*Chairman.*) You are a member of the Institution of Civil Engineers and Chairman of the South Metropolitan Gas Company?—I am.

12552. You have had a large experience in the gas industry?—All my life, and it has been a very general experience. I was at first under my father at the South Metropolitan; he was secretary, and then became engineer; I, then, was engineer and secretary, and I afterwards went on the board, and I have been Chairman for 20 years.

12553. Is all the gas in this country made from coal and cannel?—Not now; it used to be; all the gas was made from coal and cannel prior to 1890, I may say.

12554. Is there much cannel used?—There was at one time a good deal, and cannel was used for the purposes of enrichment in the South of England, but in Scotland and in the North it was used very largely for making a very rich gas. In the eighties the price of cannel went up; cannel was becoming more scarce; and, except in Scotland and Lancashire, the tendency was to reduce the consumption of cannel.

12555. Did the price of cannel rise considerably up to about 1890?—Yes.

12556. Did anything take the place of cannel?—Yes, about that time petroleum spirit and carburetted water gas were introduced. The latter had been very largely used in America; in fact, I am told that its use at last rose to the extent of about 70 per cent. of the total of the gas in the United States. It was introduced into England about 1890, and took the place of cannel as a means of enrichment.

12557. Is there any petroleum spirit used for that purpose?—Yes, and Benzol also has been largely used to enrich coal gas. Then to carburet water gas, the solar oil, as it is called, the heavier part of the distillate from petroleum, is used. First of all what is known as water gas is produced; it is then carburetted by means of petroleum oil and thus rendered luminous.

12558. Is the object of that to reduce the cost or to improve the produot, or both?—I think carburetted water gas was first introduced for two purposes—as a substitute for cannel, and also to meet the labour difficulty, because very few men are required to make a large quantity of gas by this means.

12559. Is the use of carburetted water gas increasing, do you think?—It has increased very rapidly in the last 10 or 12 years. According to the Board of Trade returns the quantity of carburetted gas made in this country now is equal to about 15,000,000,000 cubic feet, while the total make of coal gas is about 140,000,000,000 cubic feet.

12560. It is about 10 per cent. of the whole, is it?—Ten per cent. of the whole is water gas according to these returns, but they do not include the whole of the gas sold in this country.

12561. That is to say that it is not used separately, but about 10 per cent. of the total gas sold is carburetted water gas?—Yes. There are a good many undertakings which use none, but then those which do use it go as high as 25 per cent. and higher.

12562. That is a point which I am going to elicit, if possible. Inasmuch as some gas that is made contains none, some of the gas sold must contain a good deal more than 10 per cent.; would you say 25 per cent. is the highest?—No; some go as high as 50 per cent.

12563. For household purposes?—One of the suburban companies, the Tottenham and Edmonton Company, in a London suburb, I believe, so far as I can make out from their accounts, was supplying about 50 per cent. of carburetted water gas.

12564. Does that raise the illuminating power of gas?—They can make it to any illuminating power they require by increasing or decreasing the quantity of petroleum oil used. If they use about 3 or 4 gallons of oil per 1,000 cubic feet of gas they will get about 20 candle power; but if they use more oil they will get a richer gas, and if they use less they will get a poorer gas.

12565. Does it cost more per hour or less—I mean the real point *qud* consumer is how much his gas bill amounts to—does it cost him more in that form to light his house?—The reason the South Metropolitan Company have not gone in for carburetted water gas is that we find it costs more than coal gas. We get our coal cheaply; we have river-side premises, and we think that we can make coal gas more cheaply than water gas; therefore we have not adopted the system. But in other cases, such as the Tottenham and Edmonton Gas Company for example, they are rather badly placed for coal in one respect, having railway carriage as well as freight in getting it from Newcastle. That adds to the cost of their coal, which is their justification for using carburetted water gas. They say, "It costs us more to make coal gas than it does you, and therefore water gas is an advantage to us." The Gas Light and Coke Co. make a large quantity of water gas; last year 20 per cent. of all their gas was water gas.

12566. I do not think I have quite got an answer to the question I intended to put, which is this: Supposing I was living in your district, and you were living in the Tottenham district, and we were using the same number of lights in our houses for the same period of time, and supposing the price of gas per 1,000 cubic feet was the same in your district and in the Tottenham district, would there be any difference in the gas bills?—No appreciable difference, because we make a 14-candle power gas, and they make a 14-candle power gas; therefore the light obtained from a given quantity of gas would be about the same in both cases.

12567. Whether it was enriched by this petroleum or not?—Yes. The consumer would get the same amount for the same money, provided the price of gas per 1,000 cubic feet were the same.

12568. Then you say that the Board of Trade returns relate only to the gas companies and corporations supplying gas under statutory powers?—That is so; they do not include many, if any, of the village gas works.

12569. But the village gas works are not many in number, are they?—Oh, there are a good many village gas works, indeed, there must be some hundreds.

12570. And, of course, there are some private ones?—Yes, there are private ones. Then there are small towns which have gas works not under statutory powers. For instance, where I live, at Reigate, there is the Redhill Gas Company, which has an Act of Parliament, and there is the Reigate Gas Company, supplying the town of Reigate—the centre—which has no Act of Parliament, and it is not mentioned in these returns. Crawley is the same; there is a small gas works at Crawley.

12571. (*Sir George Armytage.*) They have no Act of Parliament, because they had not to borrow money for it, I suppose—they did not have to go to Parliament?—They have not felt it necessary to go to Parliament.

12572. (*Chairman.*) It is not one of the places which are supplied with natural gas, is it?—No.

12573. You mention in your statement the gas works belonging to the railway companies, such as the London and North-Western at Crewe, and the Great Western at Wormwood Scrubbs and Swindon, and the London and Brighton Railway Company?—The London and Brighton Railway Company have a small gas works at New Cross.

12574. You think that if they were included in the Board of Trade returns these works would add appreciably to the total quantity of coal given as used in gas making?—Well, it is a mere guess, but I guess it at something approaching 1,0 0,000 tons. Many iron works make their own gas, and there must be a good many hundreds of villages in the country which do the same thing.

12575. (*Mr. Briggs.*) Many collieries make their own gas?—Yes.

12576. (*Chairman.*) Do the Board of Trade returns show the total quantity of coal used for gas-making?—Yes, by the statutory undertakings.

12577. In the sense that you have put it?—Perhaps I had better hand in these two papers to you. The first one relates to companies, and the second relates to corporations supplying gas, and there is a summary of the coal used and of the gas made since 1882. It is all summarised there. (*The witness handed in the Board of Trade returns for the year ended 31st December* 1901.)

12578. Then your estimate, based upon the Board of Trade returns, and including the gas manufactures not included in the Board of Trade returns, is that

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15,000,000 tons of coal are used annually for the purpose of gas-making?—I think that cannot be far wrong.

12579. And you think that this carburetted water gas——?—takes the place of about 1½ million tons of coal.

12580. In other words, it would have been 16½ million tons instead of 15 million tons?—That is so.

12581. Would you say that the carburetted water gas is yearly increasing?—It is; it has been rapidly increasing in the last 10 years.

12582. Therefore the tendency is for the consumption of coal not to increase in proportion to the increase in the quantity of gas made?—I think so. Wherever carburetted water gas has been introduced the gas managers swear by it, and they nearly always go in for an additional installation. Perhaps here it would be well to say what is the effect of this 1½ million tons of coal taken away from the market. To make this carburetted water gas no doubt takes 1½ million tons of coal out of the market, but it would take about 250,000 to 300,000 tons of coke to make the water gas. Well, there is 1½ million tons of coal, which would otherwise be used for gas-making, taken out of the market; from that coal we should obtain for sale about half a ton of coke for each ton of coal; so that, while the carburetted water gas saves 1½ million tons of coal, it takes out of the market half that quantity (750,000 tons) of coke directly, and about another 250,000 or 300,000 tons indirectly, *i.e.*, that which is used for making the water gas. So that the effect is this: 1½ million tons of coal are saved, but there are a million less tons of coke for sale.

12583. That is another way of saying that there is not much saving?—No; instead of saving 1½ million tons of fuel there are only half a million tons saved.

12584. Therefore the coke has to be made good by coal, let us say, and it really does not make much difference *qua* coal supply or coal consumption?—No, it is only one-third of the coal which is not used that is saved; 1½ million tons less coal is used to 1,000,000 tons less of coke made.

12585. Although the coal is not used for gas-making, it really does not affect very much the market for the coal?—No; two-thirds of it would be required in substitution for the coke—or nearly.

12586. There is this point, is there not: the coal used for the purposes of making good the supply of fuel, which was lacking owing to the reduction in the quantity of coke made, might be made good from coal other than special gas coal?—Yes, that is quite possible.

12587. Therefore, so far as the gas companies are concerned, it does relieve the market and makes the price more easy to them for their particular coal?—Yes, no doubt.

12588. It is a reduction, in fact, of 10 per cent.?—It reduces the demand for gas coal by 10 per cent. now.

12589. Whatever effect that would have upon the price would be to the advantage of the gas companies or gas manufacturers?—Yes.

12590. (*Mr. Briggs.*) Would it not further enhance very largely the price of the coke which they had to sell?—Yes.

12591. So that there might be a gain in two ways?—Yes. That is one of the arguments for water gas; they say it enhances the price of coke, and it has done so materially at Tottenham.

12592. It enhances the price of coke, of which they are sellers?—Yes.

(*Chairman.*) And with a purely local market?

12593. (*Mr. Brace.*) What is the difference in price between the coke made in the method the witness is now speaking of, and the coke made from coal?

(*Chairman.*) It is not that the coke is made by a different process, but it is that gas is made from a different material than coal.

12594. (*Mr. Briggs.*) From coke, in point of fact?—It is made from coke.

12595. (*Mr. Brace.*) They consume their own coke in making the water gas?—About 20 tons of coke is required to make 1,000,000 cubic feet of water gas.

12596. (*Chairman.*) Therefore, that reduces the supply of coke for sale in that form?—We make less, and we use more coke where water gas is in vogue.

Sir George Livesey.

18 Mar. 1903.

12597. I see you distinguish between what you call companies and corporations. Do you use the word "corporations" there in the sense of municipal corporations?—Yes, it is an inclusive term—corporations, municipalities, local boards and district boards as distinguished from companies. Included in "companies" would be a few private gas undertakings which are in the list I have handed in, which have Parliamentary powers: there are a few gas works privately owned.

12598. Then you compare the quantity of gas, as I understand, in 1882 with the quantity in 1901, and these are the figures which you have ascertained?—Yes, from those Returns.

12599. You say that in 1882 nearly 5,000,000 tons of coal were used by 352 companies?—Yes, 4,928,000 tons.

12600. And 2,300,000 tons odd by 148 corporations, making a total of 7,280,000 odd tons in 1882?—Yes, used by 500 different undertakings.

12601. Whereas in 1901 there were 454 companies (an increase of about 100) using 8,500,000 tons of coal; and 251 corporations (an increase of about 110), using 5,500,000 odd tons; a total of 705 companies and corporations using 14,100,000 odd tons. Therefore, according to those figures, between the years 1882 and 1901, which is 19 years, the consumption of coal for gas-making nearly doubled?—Yes, it nearly doubled. But these figures are not quite comparable, because you see the number of undertakings included in the returns of 1882 is only 500, and in 1901 it is 705; that is accounted for by many companies going for statutory powers in the 19 years.

12602. You mean companies previously in existence?—Yes.

12603. It does not mean that the growth in the number of companies and corporations took place during that period of time?—In the 19 years the increase in the number of corporations is due largely to their purchasing the gas companies; but I should think the greater part of the new concerns introduced in the 19 years would be small ones; all the larger concerns had statutory powers before 1882.

12604. Could you give us the figures with regard to the company with which you are connected, the South Metropolitan, showing the growth?—Yes. In 1840 the South Metropolitan Gas Company was a small company, then supplying gas all over South London in competition with other companies.

12605. May I ask this one question before you go into that: Has the growth of the South Metropolitan Company been a growth by extension of the small concern which you describe, or has it been partly by the absorption of other concerns?—Up to 1880 it was a growth by extension only. The figures are: the coal used in 1840 was 5,600 tons in the year; in 1850, 17,000 tons; in 1860, 32,000 tons; in 1870, 61,000 tons; in 1880, 120,000 tons. So that in the last three decades the quantity may be said to have doubled each 10 years, or an increase of about 7 per cent. per annum. Then, in 1880, the company absorbed by amalgamation two or three other companies, and I give the aggregate figures from 1880 to 1900; in 1880 the total consumption of the South Metropolitan and the absorbed companies was 406,000 tons; in 1890, 638,000 tons (or an increase of 57 per cent. in the 10 years); in 1900, 1,131,000 tons (an increase of 77 per cent. in the 10 years). But I think I ought to qualify that by saying that the larger increase in the second 10 years from 1890 to 1900 is due to the introduction of the slot meter system of supplying weekly tenants. As a matter of fact, we introduced it in 1892. Prior to that time practically no weekly tenants had gas at all, and now we supply 140,000 such tenants. That would account in the year 1900 for, I estimate, 190,000 tons of coal. If we take that off, our increase would only have been 47 per cent. in the 10 years instead of the 77 per cent.

12606. Is this a typical company?—I think, perhaps, we have had exceptional advantages, and that our increases have been greater than others. Partly the growth of population has been greater relatively in the South of London than in the North. I believe

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Sir George Livesey.

18 Mar. 1903.

in the last 20 years the growth of population on the south of the Thames has been absolutely as great as on the north, and, of course, it is much greater in proportion.

12607. You mean as great in the aggregate?—Yes; while the population of the North of London has increased, say, 100,000 inhabitants, that of the South of London has also increased 100,000—in fact, I think it is a little more in the South.

12608. It is a more concentrated area on the South?—No, I do not think so.

12609. How far does your district extend?—We go beyond Eltham, almost to Sidcup—a mile beyond Eltham, at any rate.

12610. What is the length in miles?—It extends from the east of Eltham and Plumstead, westwards to Wandsworth, about 12 miles.

12611. Have you any competition at all?—No, none.

12612. Neither eastward, westward, nor northward?—No, there has been no competition in gas supply since 1860.

12613. How do you compare, for example, in the quantity of gas made, with the companies on the north side of the river?—Our consumption is now about half, or rather more than half, that of the Gas Light and Coke Company. Fifteen years ago it was only about 26 per cent., or 27 per cent., of the Gas Light and Coke Company, and now we are 54 per cent. of them; we have gained while they have stood still, practically.

12614. Your progress has been much greater than theirs?—Yes. It is largely due to the more rapidly increasing district, I suppose.

12615. Is electricity used as much for lighting purposes on the south as on the north of the river?—Nothing like it.

12616. That is one reason?—We have beaten the electric light people on the south; they get very little encouragement.

12617. (*Mr. Brace.*) So that you are in a very enviable position for supplying gas, you have no competition with the gas, and you have killed the electric light competition?—And we have beaten the mineral oil by the slot meter. We are on very good terms with our consumers, and we have cultivated friendship with our consumers. My father began it; he died in 1871, and it has been continued, with the result that our customers are very well disposed to us, and when the electric light people go to them they say: "We are satisfied with the gas company."

12618. (*Chairman.*) Have you had any tests relatively of the electric light and of the gas for the purposes of street lighting?—I can give an instance. Bermondsey have an electric light installation, and last year their surveyor reported that to light 23 streets with electricity would cost at the rate of 1s. 8d. per candle power per annum, but it could be done with gas at a cost of 7½d. per candle per annum.

12619. (*Mr. Briggs.*) Would that be by using mantles and incandescent lights?—Yes; we have introduced that in all but two or three parishes, which have the electric light. We undertook to make the change ourselves, the expense of making the change coming out of the saving in the price of gas; they were to continue at the old price until the cost of the alteration was defrayed. With the Bermondsey people the cost of incandescent street lighting was about one-third the cost of the electric, but they were committed to electric lighting.

12620. (*Chairman.*) Was the light as good?—It was calculated at per candle, so that it was perfectly comparable. The electric light was to be arc lighting up to midnight, and incandescent after midnight—the incandescent was a most miserable light after midnight—and we were giving the Welsbach all night.

12621. Does the use of the Welsbach reduce the consumption of gas as well as increase the light?—Yes. I will give you an instance, although it is a small one. A friend of mine in one of his offices in the City told me he had eight flat flame burners. He said, "I have substituted for those eight flat flame burners" (which I may say were burning 40ft. of gas per hour—5ft. each) "three incandescents, and I have got a better light, and those are only burning 12ft. per hour in the aggregate." I think you may put it in this way, that a consumer can treble his light at about half the cost—he can increase his light by six.

12622. (*Mr. Briggs.*) For the same money?—Yes.

12623. (*Mr. Maclay.*) Is that as against electricity?—No, gas against gas—by the Welsbach. I may put it in this way: The best gas burners will only give a light with ordinary gas burnt in the ordinary way, equal to three-candle power per foot of gas—many of them do not give two; the Welsbach mantle will easily give 20-candle power per foot of gas—you may get 30-candle power out of it—but take it at 20, which is gradually reduced after the mantle has been in use a little while to 18, as against three-candle power. So that you get six times the light for the same quantity of gas.

12624. (*Chairman.*) The general adoption of the Welsbach mantle will considerably postpone any requirement for larger mains in your district?—Possibly; it is singular that Sir Frederick Mappin in his speech at the Sheffield Company's meeting, reported in yesterday's "Gas Journal," was referring to a reduction in their sale of gas in the half-year under review, and said he accounted for it by the great increase in the use of Welsbach mantles in that half-year.

12625. How many metropolitan companies are there in London?—There are three known as the metropolitan companies, the Gas Light and Coke Co., the Commercial, and the South Metropolitan.

12626. Which are the suburban companies?—There are a number of suburban companies. I have taken out the figures for 10 suburban companies from "Field's Analysis of Gas Accounts."

12627. How much coal do these 13 companies use?—I have taken out the figures for 1881, 1891, and 1901. In 1881 these 13 companies used 2,252,000 tons; in 1891 they used 3,452,000 tons; and in 1901, 3,872,000 tons. The increase in the first 10 years was 1,200,000 tons, or 53 per cent.; the increase in the second 10 years was 419,000, or 12 per cent.; it would have been more but that these companies saved about half-a-million tons of coal by the use of water gas. Still, even if they had not used any water gas, their increase in the second 10 years would only have been 26½ per cent., against 53 per cent. in the first 10 years, showing a rapid falling off in the increase in the consumption of gas. We used to reckon it 100 per cent. in 10 years—that it doubled once in 10 years prior to 1880. After 1880 the London companies increased only 53 per cent. in 10 years, and in the second 10 years, if they had used coal for all their gas, they would only have increased 26½ per cent. So that that indicates a very rapid declension in the increase.

12628. Have you any figures for other Corporations outside London?—In these tables the figures are given for seven Corporations supplying gas. The Corporations are Birmingham, Bolton, Leicester, Manchester, Nottingham, Oldham, Salford; and there are also seven companies: Bath, Brighton, Bristol, Newcastle, Plymouth, Portsea, and Sheffield. For these I can only go back to 1883, because prior to that Field only dealt with the London companies. But in 1883 these 14 provincial undertakings used 1,373,000 tons; in 1891 (eight years later) they used 2,075,000 tons; and in 1901, 2,729,000 tons. The increase in the first 8 years was 702,000 tons, or 51 per cent., against 53 per cent. in 10 years of the London companies. In the last 10 years the increase was 654,000 tons—a smaller absolute increase—but that only amounted to 31½ per cent.; or adding their water gas it would come to 40 per cent. The rate of increase, therefore, in the provinces has been maintained at a higher rate than in London in the last 10 years.

12629. Those figures seem to indicate that the increase in the first 10 years was about the same rate (London and country), but that in the second 10 years the progress had been greater as regards consumption of coal in the country?—Yes, and I think the main cause of the difference is the practically standing still of the Gas. Light and Coke Co. during the last 10 years. Their business has hardly increased at all.

12630. Would it be due at all to the greater proportionate use of carburetted water gas? Apparently the saving was greater (but, of course, the total quantity is greater) in coal owing to the use of carburetted water gas in London?—Yes, to some extent

12631. Then would the Welsbach mantles not make more progress in London than they would in the country?—I do not think there is much difference. The fact is that up to 1899 there was very little done with the Welsbach mantle; it is only in the last year or two that they have come largely into use.

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12632. (*Sir George Armytage.*) They are used more in the streets now?—Yes, much more; in fact, until two or three years ago they could not be used in the streets in large towns because of the vibration. They have improved the mantle, so that it now stands vibration, and last year we succeeded in getting the price of mantles materially reduced.

12633. (*Mr. Briggs.*) Then is it not a fact that in London, especially in the Gas Light and Coke Co.'s district, electric lighting is developed more largely than in the provinces, which would have the effect of decreasing the amount of gas used?—Yes, very much more.

12634. (*Sir George Armytage.*) Probably that is the reason of their standing still, as you say?—Yes.

12635. (*Chairman.*) Have they an incandescent burner and mantle of a small size fitted for houses now?—I think the smallest size is calculated to burn a little over 2ft.—2½ft. an hour at the outside.

12636. Of course, the big ones are hardly suitable for an ordinary room, are they?—Well, I do not know that.

12637. Such as they were to start with—they give such a glare?—Well, if you put three *here* in the place of these nine electric lights it would be better.

12638. (*Sir George Armytage.*) You would have more light?—Yes. There is a very clever arrangement they are now making of a reflector below the burner throwing the light on to the ceiling.

12639. (*Chairman.*) You mean as regards the incandescent burners?—Yes. Of course, I am prejudiced, I suppose, but I would much prefer to have incandescent lights than these electric lights. The electric lights try my eyes more.

12640. Then you say the rate of increase in the last 10 years in the actual consumption of coal was only 19½ per cent?—Yes.

12641. If to this be added coal saved by water gas the increase would have been 32 per cent.—that is to say, the increase of gas?—Yes.

12642. You say this shows a considerable falling off in the rate of increase in the decade prior to 1880?—Yes. Prior to 1880 it used to be approaching 100 per cent. in the 10 years, and then it dropped to a little over 50 per cent., and now it has dropped to about 30 per cent.

12643. You attribute the falling off to the introduction of cheap mineral oil, and the introduction of electric light later, as I understand?—Cheap mineral oil came into use in the seventies; oil for lighting used to cost 5s. or 6s. per gallon, and then, after the mineral oil was introduced it could be got for as many pence, or about that. Then, later, came the electric light, and these two have been the greatest competitors that gas has ever had—of course, it had none before.

12644. Is the use of gas extending for cooking and heating?—Very largely, as it has been doing since 1870.

12645. And for power?—Yes.

12646. Will that go on, do you think?—I think so; I think there is good reason to expect that to go on. Of course, that depends upon whether gas becomes cheaper or not. If we can get coal cheaper, then we shall sell gas cheaper; and, moreover, if we are allowed to reduce the illuminating power, which is now of no importance whatever (because the incandescent mantle has come in), we shall then be able to make a poorer gas, and to make it cheaper, and it will then become much more used for power purposes than it has been, I should think, and for heating.

12647. Do you anticipate the competition which some people predict of a gas for purely power and heating purposes of very low quality?—Yes, there is something in that; but I think that will not affect us in places like London; it will be more in large manufacturing districts, for instance, like the Mond Gas Company, which is started to supply the district around Birmingham. Where gas is required in large quantities for power purposes, such a company would probably compete with the gas company.

12648. Have you any knowledge on this point; gas for the purposes of a gas engine—for power purposes—can be more economically used, can it not, if it is made of the poorer quality—I do not know whether that is the right term, but large in quantity and low in quality?—No; taking the Mond gas, its calorific power is about what is called 140 British thermal units, whereas the lighting gas—the coal gas—which is supplied is 600 British thermal units. The coal gas has four times the heating power of the Mond gas, at least. A consumer using it for power purposes could very well afford to give four times the price; but if the Mond gas is going to be sold at 6d. per 1,000 cubic feet (I think they put it at less than that), that would be equivalent to coal gas at 2s.

12649. Do you think the suggestion is a practicable one, that we could be supplied in London from the districts where the coal pits are?—No, not at all; I do not think that is at all practicable. That has been thought of a number of times in past years, but it has always been dismissed as impracticable. The cost of sending the gas would be greater than the cost of bringing the coal.

12650. You mean the cost of pumping it?—Yes.

12651. Is that due to the friction in the pipes?—Yes, and the capacity of the pipes which you would want. Of course, if it were to be pumped, it would have to be pumped under very heavy pressure; otherwise the pipes would require to be such an enormous size.

12652. Your experience is that, as gas becomes cheaper, its use increases?—Yes, there is no doubt about that—especially for heating and power.

12653. And you have not reached anything like the limit of that yet?—No, I think not.

12654. (*Sir George Armytage.*) Do you make a separate charge for heating and power?—No.

12655. It is the same as light?—The same as light. We allow a small discount in proportion to the quantity used. But in many cases there is a considerable allowance made for gas used for power. I think some allow too much, and it is rather unfair to the consumer who uses gas for lighting.

12656. (*Chairman.*) But if the use of it extends industries in a district, the same persons benefit, do they not?—Yes, of course.

12657. Is there any progress in the use of gas for heating purposes by means of stoves in this district?—Oh, yes, there is a great deal of gas used in the form of gas fires. We find that out; if there is a burst of cold weather the consumption of gas goes up enormously.

12658. Do you supply stoves?—We supply stoves, and we supply gas fires also. The South Metropolitan have stoves at rent; these are cooking stoves, and, of course, there are a good many owned by consumers; we have about 110,000 ordinary consumers of whom 59,000 have cooking stoves—more than one-half. On the 31st December last we had 139,000 slot meter consumers, of whom 112,000 have cooking stoves. We had at rent 51,600 gas fires, but that is nothing like the quantity in use; the gas fires are bought by the consumers very largely, but the cooking stoves are mostly hired. In the Crystal Palace District Company they had 8,000 ordinary stoves at rent, and 11,500 with slot meters.

12659. Then you are of opinion that the use of gas for heating purposes and what you call gas fires is extending?—Certainly.

12660. You say the necessity for the production of illuminating gas is fast disappearing?—Well, I say it has disappeared. The Welsbach mantle ought to be used universally, and then there would be no necessity for illuminating gas at all.

12661. Then you could supply gas at a cheaper rate?—Our difficulty is that we do not know how to make it yet. What we want to do is to make a large quantity of poor gas, say, of eight or nine candle power.

12662. (*Sir George Armytage.*) You mean you want to be able to adapt your present plant and your present premises to doing that?—Yes; if we knew how to do it, we would adapt it, but we do not know yet how to do it.

12663. You want some sort of Mond system?—Yes. The Mond gas is not good enough; the heating power of Mond gas is too low to render the mantle luminous.

12664. You call it about a quarter as good as yours, do you not?—Yes. What we want is a gas of about 350 to 400 British thermal units power.

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Sir George Livesey.
18 Mar. 1903.

12665. (*Mr. Briggs.*) That would be sufficient?—That would do for the Welsbach; we can make gas of 120 or 130 British thermal units, and we have gas at 600 British thermal units, but between those two we have nothing practicable. We have water gas, it is true.

12666. You could reduce those and mix them with your water gas, and cheapen your gas in that way?—Yes.

12667. That might be a way out of the difficulty?—That is the only way apparent at present.

12668. (*Chairman.*) Does the cost at all follow the scale of thermal units in the sense which you have described?—Not the selling price. Of course, the selling price of gas includes all the cost of distribution and interest on capital; but the cost of the manufacture does approximately follow.

12669. Are you in favour of the enrichment of the illuminating power of gas?—I think it is an utter mistake. Hundreds of thousands of pounds have been wasted annually by utterly useless enrichment.

12670. You would enrich it by means of the mantle?—Yes, by means of the mantle.

12671. Parliament has approved that principle, you say?—Yes, in 1900 the first step was taken by reducing the illuminating power from 16 to 14 candles. That Act was promoted by our company, and each year since there has been an increasing number of Acts for reducing the illuminating power, and it is accepted as the right principle.

12672. (*Sir George Armytage.*) What was the old standard minimum?—16 candle power in our care, which was reduced to 14. When I was giving evidence before the Committee, Mr. Oldroyd was the chairman, and the evidence all tended to a much lower standard than 14 candle power. He put this question to me: Why do you stop at 14? and my answer was, Because I think it is as much as Parliament can swallow at one dose. We shall go below that in future years, no doubt.

12673. (*Chairman.*) Did Parliament put upon you any obligation to reduce the price proportionately?—We volunteered that—the reduction of 1d. in our standard price per candle. But last year the West Ham Company were allowed to reduce the quality at the rate of ½d. per candle power.

12674. The Welsbach mantle has greatly helped you in this respect?—Yes.

12675. In fact, you refer to that as being practically the way out of the difficulty?—Certainly.

12676. And you put the Welsbach incandescent mantle as giving 15 to 20 candles per foot of gas, compared with the old burner, which gave about three candles, or even less?—Yes—generally less. If the Welsbach is used under pressure, as it is at Blackfriars Bridge and the Tower Bridge (that is to say, the gas is supplied under pressure equal to about 10in. of water), you get as much as 30 candles per foot of gas.

12677. Is there any improvement in the mantles as regards their life?—I think they are gradually improving them.

12678. Is the life dependent upon, or does it approximate at all, or follow the line of the candle power?—I suppose these mantles, worked under pressure, would not last so long, only then they are made stronger to meet it.

12679. They are made stronger, therefore a mantle subjected to giving out 30-candle power would last as long as one giving 20?—Yes, nearly. I think the deterioration of the mantle is due to a gradual loss of its life-giving properties.

12680. Is it affected by the high temperature?—I suppose that is it—that in course of time they give rather less light. But a good mantle will start at 20 or 21 candles per foot of gas, and work down to 17 or 18, and will continue at that for a long time—many weeks or months.

12681. But with the present price of mantles I suppose it is really economical to renew them?—Well, to renew them when necessary. Sometimes a mantle will last a very long time. I have one in my house that was used every night. I had it in use, I think, for 18 months.

12682. It was perhaps a favourable situation with regard to wind, and so on?—No. It was lighted every night by a match.

12683. (*Mr. Briggs.*) No bye-pass?—There was a bye-pass in the burner, but I have done away with it. I think the flame of the bye-pass tends to deteriorate the mantle. To begin with, it creates a current of air, and the air carries dust, and the deterioration of the mantle is due partly to the accumulation of dust on its surface.

(*Mr. Briggs.*) Yes, that is my own experience.

12684. (*Chairman.*) Then the practical effect of the use of mantles, as I understand, is to reduce the price of gas from 2s. 6d. to 6d. per 1,000ft.?—To be on the safe side, I take it that you increase the light from three candles to 15 candles per foot of gas—that is five times—and that is equivalent to dividing the price of gas by five—light for light.

12685. Or giving you five times as much light for the same money?—That is so.

12686. It does not appear always in the gas bills?—Well, of course, there is no doubt that people are requiring much more light now than they did 20 or 30 years ago.

12687. I think you have told us that the incandescent mantles are coming into general use in this country?—Yes. The gas companies are undertaking in many cases the maintenance of mantles at a fixed charge to the consumer, employing men to go round to see to them.

12688. Is it a fixed charge per light?—Yes.

12689. Has that extended to the cottages?—Well, no. They buy the mantles themselves. I was talking to some of our workmen the other day, and I asked them how they managed with regard to mantles, and where they bought them. They said, "We buy them of the company, and put on the mantles and take them off," and one man said, "I have a mantle over the kitchen fire, and the burner gets clogged with dust. I take the mantle off from time to time and clear out the dust from the burner and put the mantle back again."

(*Mr. Brace.*) He is an expert. They always go to pieces when I even look at them.

12690. (*Chairman.*) Have you any estimate of the number of mantles used per year in this country?—Well, I made inquiry last week of the Welsbach people, and they estimated that about 30,000,000 mantles per year are used in this country now, but the number is fast increasing.

12691. I suppose you have made no interesting guess as to what proportion of the gas those mantles are applied to?—No. With regard to our street lamps, we use about six to eight mantles per year for them.

12692. (*Mr. Briggs.*) Per lamp?—Per lamp. Each mantle lasts about six weeks or two months on the average.

12693. (*Sir George Armytage.*) What do the mantles for street lighting cost?—We get the mantles at prices ranging from 2½d. to 4d. for the streets.

12694. (*Chairman.*) Those are the larger size, are they?—The larger size.

12695. (*Sir George Armytage.*) About 2s. per year?—Yes; but then, of course, there is the expense of changing and looking after them. The use of those mantles has enabled us to reduce the cost of street lighting very materially. We used to charge £3 5s. per lamp, and we can do it for from £2 to £2 10s., according to the size of the mantle—and we are doing it.

12696. (*Chairman.*) All incandescent mantles are used on Bunsen burners, are they not?—Yes. A luminous gas would not do for an incandescent mantle; it must be a gas which will not deposit carbon. If you put any substance in a gas flame you get carbon deposited on it. Put a kettle over an ordinary gas flame, and you get a lot of lamp black. Therefore, the mantle being a solid substance, must have gas supplied to it in such a way that carbon cannot be deposited, and the only way is to mix air with it before it is consumed in the Bunsen burner.

12697. Is the use of gas extending for gas engines working dynamos?—I do not think it is very much. It is in some cases, but the South Metropolitan Gas Company, out of 110,000 ordinary consumers, have only about 50 who have gas engines to work dynamos; the Crystal Palace District Gas Company, who have 17,000 ordinary consumers, have 19 who are using gas engines to work dynamos; and the Commercial Gas Company, out of 25,000 ordinary consumers, have be-

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tween 20 and 30 who use gas engines to work dynamos. But in nearly every case where they have installed a gas engine to work a dynamo to supply electric light the consumption of gas has largely increased.

12698. For installing electric light?—For supplying electric light.

12699. (*Sir George Armytage.*) You mean the quantity of gas used in a particular house is greater when the occupier is running the electric light than it was before he had the electric light?—I can give you the exact figures. I will take a case of a private house at Forest Hill, in which, the year before the gas engine was installed to work the dynamo, the consumption was 212,000ft.; the year after it was 229,000ft.—in this case practically the same. Then other cases, 105,000ft.—132,000ft., 114,000ft.—154,000ft., 223,000ft.—451,000ft. (more than double), 150,000ft.—175,000ft. These are all private houses. Then there is one which was 61,000ft. before they had the electric light, and 669,000ft. after they got it in.

12700. (*Dr. Le Neve Foster.*) Well, he got a lot more light?—He must have, and therefore that is not a fair comparison. But here is the case of a provision store at Upper Norwood. That was 1,290,000ft. before the gas engine and electric light, and 1,410,000ft. after. I think you may take it that the installation of a gas engine to work a dynamo to supply electric light does not reduce the consumption of gas.

12701. But it may give the consumer more light?—Yes, it may give him more light.

12702. (*Chairman.*) And in a form in which he prefers it?—The same is the case with the other companies. Here is the case of a theatre at Woolwich. They consumed 997,000ft. before they had this gas engine, and 1,801,000ft. the year after.

12703. (*Sir George Armytage.*) They would use a good deal for stage-lighting, no doubt, which they could not use gas for?—I daresay. Then a draper at Clapham, 520,000ft. before and 973,000ft. after.

12704. (*Mr. Brace.*) There would be some explanation, surely, of those increases? People would not go to the expense of putting in an electric light installation unless they were going to have some advantage out of it?—(*Chairman.*) Well, they get a greater show in the case of a draper?—Here is a case in Broadway, Deptford. There is a large clothier's shop there—a very large corner shop. They have installed electric light work by gas engine—for the sake of advertisement, no doubt.

12705. (*Dr. Le Neve Foster.*) And perhaps their goods suffer less?—Well, not much. Gas does not do the harm that people think.

12706. (*Chairman.*) Now as to possible substitutes for coal in the production of light, do you think that oil lighting, such as the Kitson light, is affecting the use of gas?—It is a very splendid light, and it is a very cheap light, but it will not appreciably affect the use of gas.

12707. Is it suitable for large areas?—It is, but where gas can be had the trouble of a separate installation of a different kind is very much against it.

12708. (*Dr. Le Neve Foster.*) But where gas cannot be had it is a very great advantage, is it not?—Yes, there is acetylene, too, where gas cannot be had.

12709. Is acetylene making much more progress?—Those Board of Trade returns I have given you say it is equal to 89,000 feet, or something like that. It is not much.

12710. (*Chairman.*) Yes, I see. "Including 15,000,000,000 cubic feet of water gas, and 89,000 of acetylene gas"?—Yes. I ought to say that at some places where these people have installed dynamos for electric light, they probably use the electric plant for power.

12711. Yes, quite so. You say the only practical substitute is the production of carburetted water gas from coke. Is as much as 25 per cent. of gas in any case used as carburetted water gas?—Yes—more.

12712. You have told us of one case where you thought there was 50 per cent. used?—Yes.

12713. Will the make of water gas in a few years increase, do you think?—Yes, I think so. I think there is every reason to expect it; but at present only a comparatively small proportion of gas works have the necessary plant.

12714. That is a method of reducing the cost, is it?—We do not find it so. One great reason for the introduction of water gas is to enable the gas people to deal with the labour question. Two or three men can do the work of 50.

12715. In water gas?—Yes. We are happily in a different position. We do not need anything to save labour.

12716. Then is this your estimate: "If the production of water gas were increased to double its present quantity, or should it reach 20 per cent., it will take the place of about 3,000,000 tons of coal?"—Yes.

12717. That is per annum?—Yes.

12718. "It is produced from Coke. It therefore takes a certain amount of coke out of the market, estimated roughly at 2,000,000 tons?"—It is easily remembered. It is 3,000,000 tons of coal saved to 2,000,000 tons of coke less for sale. This includes the coke used in making water gas.

12719. "Then 600,000 tons of coke are used in making 30,000,000,000ft. of water gas?"—Yes, that is so.

12720. About 20 tons of coke make 1,000,000ft. of water gas?—That is so.

12721. Well then, summarising the result, the three influences which, in your opinion, tend to check the consumption of coal for gas-making are mineral oil lighting, electric lighting, and carburetted water gas?—Then I would add another: reduced illuminating power. We are making 10 per cent. more gas already in the South Metropolitan by the reduction of illuminating power—10 per cent. more gas from the same coal.

12722. That is another way of saying that the extension of the use of mantles diminishes the quantity of coal necessary for lighting purposes?—Yes, because you can make a poorer gas.

12723. And it increases the illuminating power?—Yes. The poorer gas gives the same light with a mantle—quite as good a light as the richest gas.

12724. (*Sir George Armytage.*) Is that so? I mean to say, no doubt the mantle is very bright, but does it give the same light as the better quality of gas?—That was proved in evidence before Mr. Oldroyd's Committee in 1900: experts who had made the experiments said that they had obtained a rather better effect—not much, but still a little better effect—with 12 candle gas than with 16 candle gas.

12725. (*Chairman.*) But that would largely reduce the quantity of coal?—Yes; you may take it that the mantle is no worse with the poorer gas.

12726. (*Mr. Maclay.*) You said you had been able to reduce the price of the street lighting from £3 5s. per lamp to £2 10s. That is not proportionate to the increase of light of 5 to 6 times the amount which you speak of in the use of the Welsbach mantle?—(*Chairman.*) He reserves a little of the advantage, I suppose?—We give them 70 to 80 candles instead of 15 candles. We increase the light and reduce the price at the same time, giving them 70 or 80 candles instead of 15.

12727. Do you know how long the patent lasts for this mantle?—The patents are out in 1907.

12728. And then after that anyone may make these mantles?—What we did last year practically settled the question. Several gas companies associated themselves, and we came to an arrangement with the Welsbach people that we should have the option to buy of other makers or make our own mantles upon payment of ¼d. per mantle royalty. We deal, however, largely with the Welsbach Company.

12729. (*Mr. Briggs.*) So that that is all there is in it?—Yes, only ¼d. per mantle. We do not make them; they sell them to us.

12730. Where you maintain the mantles do you also now supply, maintain, and fit them?—Yes.

12731. So that you take away from the consumer all the trouble of the change?—Yes; we do that.

12732. That seems to have given a great impetus, I should imagine, to the use of the mantles?—Yes; we

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Sir George Livesey.

18 Mar. 1903.

send canvassers out, and in some cases we have taken the consumers away from electric light and got them back to gas in that way.

12733. With regard to the calorific power of the gas, I suppose the 14 candle power gas has a less calorific power than the 16 candles?—Yes, it has slightly.

12734. Then for use in gas engines it would be *pro tanto* less powerful?—I think the reduction is from about 640 to 600 British thermal units.

12735. And the power in the gas engine would be according to the thermal units?—Yes.

12736. So that the lower gas would not be as useful for gas engines as your present gas, if it were used still further?—No, it would not.

12737. I conclude from what you say that you do not look upon the enrichment of even a worse gas than that, by benzol, as being likely to come in to save coal much, do you?—No, I do not think so. I think all enrichment is a mistake.

12738. Even in the case of water gas of a very low quality?—Well, I do not know. We cannot supply non-luminous gas; there must be certain places where flat flame burners will be used; but by improving and adapting the flat flame burners to the quality of the gas supplied, you get a great deal more light out of it than you think.

12739. And you hold that for mere lighting, say, of a passage, that would be sufficient; even the low candle power you speak of would be quite sufficient?—It would be quite sufficient, because burners could be made that would develop the utmost light from that gas.

12740. (*Dr. Le Neve Foster.*) How is the solar oil introduced to the water gas?—The carburetted water gas is made first. A deep furnace is filled with coke, an air blast is sent through it to raise it to the proper state of incandescence, then the air blast is shut off, steam is turned on, and the steam is decomposed into its oxygen and hydrogen; the oxygen becomes carbonic oxide, and you get a mixture of hydrogen and carbonic oxide gas coming out of the producer. Then this goes into heated chambers—cylindrical vessels filled with bricks, arranged in an open manner. The oil is first of all vaporised, it is then mixed with this water gas, and goes through this heated chamber, and is there made into what they call a permanent gas. There is a double operation: water gas is made first, and then it is carburetted by going through these heated chambers with the oil vapour.

12741. Is the Dellwik process used sometimes?—Yes, but it is not much used in this country. The two processes are, first, that of Humphrey and Glasgow—the "Lowe" process of America—and the other is by another American firm, the Economic Water Gas, a modification of the "Lowe" process. But the Dellwik process has not come much into vogue here. I think it is a very good one, but it is not much used yet.

12742. Did I understand you to say that you thought it was unfair to make a reduction in the case of gas used for power instead of light?—To make too large a reduction, I think it is unfair to the light consumer.

12743. But is it not a fact that the consumer of power wants his power during the daytime, at a time when the gas works have to do less than in the evening or at night? Is not that a reason for giving him the power gas cheaper?—Yes, but that would not amount to much. I have gone into it; it is a question of interest on the mains and gas-holders, and that will not amount to more than 2d. per 1,000ft.

12744. You were telling us about the greater amount of light that you get with the Welsbach burner when you use the gas under pressure?—Yes.

12745. I suppose that pressure would be too great for using in private houses?—No, I do not think so. I am contemplating that we shall supply gas under sufficient pressure; it is only nine inches of water pressure that is necessary—not more. The Keith compressor is used, and Sugg has got a compressor, a little pump which is worked by the ordinary water supply from the town mains, which compresses the gas and supplies it to Southwark Bridge, Blackfriars Bridge, and the Tower Bridge; and we are doing it now for clusters of shops.

12746. (*Chairman.*) Does it require a separate compressor at each establishment?—No. At Sydenham there is a row of new shops, and one compressor supplies gas for the outside lighting of all that row of shops.

12747. (*Dr. Le Neve Foster.*) Then the gain of light that you get is much more than the cost of compressing?—Yes, much more. I think the time will come when we shall be able to supply our ordinary gas at nine inches pressure in the mains, but at present we cannot do that.

12748. Is that on account of leakage?—No; one thing is that none of our meters would stand that pressure. We should have to have a pressure reducer at those places where they did not want a high pressure gas.

12749. (*Sir George Armytage.*) But then, as you say, the way in which this pressure is put on at Blackfriars is so simple that there would be no difficulty in a man having his own gas compressed after it passed through the meter?—None whatever—if his consumption is large enough.

12750. (*Sir Lindsay Wood.*) What is the consumption of coal per candle power for electric lighting?—That I do not know.

12751. Is it much less than it would be with gas?—Well, one would think so, but I really do not know what the consumption of coal is for electric lighting. I should think it must be less.

12752. Considerably less, I should think?—Yes, it must be.

12753. (*Chairman.*) Have you formed any view upon this large question of whether the steam boiler is going out of use?—Well, Sir Frederick Bramwell said it would do so, and the steam engine also—that all power would be by gas engines.

12754. But you have not seen the tendency yourself?—Yes, I think so; I think it is going out of use now, particularly as gas engines can be constructed for such high powers.

12755. That is to say, 4,000 or 5,000 horse power?—Yes. What they will do will be to make what is called producer gas, and use that direct in the gas engine. I think the steam boiler is doomed, but it will be some time dying.

Mr. CHARLES EDMUND STROMEYER, called; and Examined.

Mr. Charles Edmund Stromeyer.

18 Mar. 1903.

12756. (*Chairman.*) You are the chief engineer of the Manchester Steam Users' Association?—Yes.

12757. I suppose your evidence will be directed mainly to showing what economy is possible as between, shall I say, the most extravagant form and the most modern form of steam engine?—No, I can hardly do that. I have tried to show what the improvement has been in steam engines during the last 25 years, and my proposed evidence is directed towards showing what might have been done by saving heat.

It was known even in the days of James Watt that increased steam pressures would result in increased steam engine efficiency, but designers were hampered for want of suitable materials, cast iron, copper, and even wood being used in the construction of boilers. It is only a few years ago that one of our members discarded a copper steam boiler. The invention of puddled wrought iron, about a century ago, enabled

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steam pressures to be gradually raised to about 100lbs. per square inch, the highest point being reached about 1880, but difficulties were experienced with the furnace plates, these, if made thick enough to withstand high pressures, laminated and blistered when exposed to furnace temperatures. About 1880, Siemens introduced mild steel, a strong and homogeneous material, and boiler furnaces could in consequence be made probably one inch thick. Even with three-quarter inch thickness—that is the limit fixed by the Board of Trade and by Lloyds for furnaces—boilers can be designed to work at 200lbs. or 300lbs pressure.

12758. Are there any boilers working at 300lbs. pressure?—There are some small ones; I believe there are some marine boilers working at 250lbs. pressure, but they are few. There are also some working at 300lbs. for test purposes, but the number is so small that it would have no effect upon any question of economy. The first modern high-pressure triple-expansion engine using high-pressure steam was built for the ss. "Aberdeen," and since then steam pressures on steamers have been increased from 80 and 100lbs. to 150 and 200lbs. The saving effected by this change is said to be from 10 to 15 per cent. The old engines were, of course, rather uneconomical; the design even for the low-pressure engine was not as good as it might have been, and when triple-expansion engines were introduced, improvements due both to the high pressure and to the improved design came together, and many engines showed improvements of quite 30 per cent. Attempts are made every now and then to increase this saving, but the results are comparatively unimportant. Marine engineers have certainly had every inducement to improve their engines and boilers, for not only does the engineering department of a steamer head the list of a vessel's expenses, so that even relatively slight savings are at once felt, but steamers are constantly being renewed, and engineers have, therefore, frequent chances of applying improvements. The case is different ashore. If a factory does not pay its way, the owners are rarely bold enough to build a modern one. They cannot pull the old one down before rebuilding, because during the intervening year or two their best hands would find employment with competitors, and their trade would go in the same direction. Modern factories would, of course, be provided with the best engines and boilers, but old factories are not easily improved; besides, the expenses of the engine department are nearly always small in comparison with the wages and with the cost of raw material, so that a saving of even 50 per cent. in fuel would often not exceed one or two per cent. of the total working expenses. Another reason why land engines are not modernised is that certain savings effected in the engines cause other losses in the works. Thus, in one factory the engines are worked uneconomically at high pressures, with little expansion and no condensation, because practically all the exhaust steam is used for boiling and other purposes.

12759. Is it true to speak of it, therefore, as being worked uneconomically, *qud* engine itself?—Yes, the engine itself.

12760. (*Sir George Armytage.*) From the engineer's point of view?—From the engineer's point of view it is decidedly uneconomical. In the works I am thinking of, they are using some turbines, and they are exhausting against a pressure of 15lbs., which, I believe, is considered highly uneconomical; but the exhaust steam main runs right round the works—it is a brewery—in which they require about 15lbs. pressure for boiling purposes in the brewers' coils. They gain there what they lose in the engines.

12761. (*Chairman.*) Therefore, although the engines are being worked uneconomically, the consumption of coal at the factory is probably not greater than it would be if they were divided and the engines worked economically, and the steam required supplied in other ways?—Yes. I believe, in this case, it is more uneconomical in the way they are working than if they were to have economical engines, and to have an extra steam supply. There are many works in which the engines are uneconomical, and where the waste steam is not utilised; but even in such works the greatest saving would be effected, not by modernising the engine, but by carefully utilising the waste steam, and, I should add, the waste heat. In 1877, the Manchester Steam Users' Association compiled a report on the indicated horse power and coal consumption of 101 works. A comparison is made on page 6 of that report, from which I have extracted the following table:—

TABLE I.

Gross and Net Coal Consumption per I. H. P. of Factory Engines in 1877.

Type of Engine.	Compound Condensing.	Single Cylinder Condensing.	Non-condensing.
	Lbs.	Lbs.	Lbs.
Mean boiler pressure - - - - - -	6·84	4·75	5·33
Coal per I.H.P.:			
Gross - - - - - -	4·79	5·85	12·34
Net - - - - - - - - -	3·54	4·70	8·79
Difference for heating - - -	1·25	1·15	3·55

This Table shows the relative efficiency of compound condensing engines. We got returns from those works as to the gross amount of coal burnt, and the net amount of coal burnt; the net amount of coal burnt would include the coal required for banking fires over-night, it would be the full weight of coal used during the week. Comparing this coal used per indicated horse power during the whole week, we find that the compound condensing engines use 3·54lbs., the single cylinder condensing used 4·7lbs., and the non-condensing engines use 8·79lbs. During the short time at my disposal it has not been possible to revise this Table, but a few of the old works continue to send in returns. These are given in the following Table:—

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Mr. Charles Edmund Stromeyer.

18 Mar. 1903.

TABLE II.

Pressures and Coal Consumptions per I. H. P. in 1877 and 1902.

Report Number.	Works.	Pressures.		Coal Consumptions.					
				Gross.			Net.		
		1877.	1902.	1877.	1902.	Gain.	1877.	1902.	Gain.
		Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
2,004	Cotton Mill	78	82	3·02	2·13	0·89	–	–	–
2,013	„ „	70	80	4·18	3·63	0·55	–		–
234	„ „	68	93	4·48	4·00	0·48	4·13	–	–
243	„ „	66	110	4·50	3·53	0·97	–	–	–
2,317	Flax Mill	63	130	4·66	3·60	1·06	3·10	–	-
25	Machine Works	70	70	3·95	5·00	(loss −1·05)	–	–	
2,148	Pumping Station	59	59	–	4·30	7 or 8*	11·36	–	–
1,283	Corn Mill	60	180	4·29	1·87	2·42	–	–	
1,501	„ „	65	65	3·1	2·00	1·12	–	–	

* Comparing gross with net.

In this Table there are four cotton mills; two of them have increased their pressure; the first two mills are practically unaltered, but the third and fourth mills have increased their pressure from 68lbs. to 93lbs., and from 66lbs. to 110lbs.; but whether the pressure was increased or not, all those four mills show a gain from about ½lb. indicated horse power up to 1lb. Then there is a flax mill, in which the gain is 1lb., accompanied with an increase of pressure from 63lbs. to 130lbs. There is a machine works, in which the pressure was not increased, and where there has been a loss of 1lb.; they are possibly, I should think, now over-working their engines and boilers. Then there is a pumping station, in which evidently great improvements have been made, because there is a saving of 7lbs. or 8lbs. per indicated horse power. Then, in two corn mills there is a saving of 2·4lbs. and 1·1lbs. From these few cases it will be seen that the fuel consumption has been reduced. The same conclusion can be drawn if we compare the summary Table III. with Table IV., which contain the classified mean values of the gross fuels per indicated horse power per hour.

TABLE III.

Classified List of Mean Coal Consumptions per I. H. P. in 1877 in 59 Works.

Works and Numbers.	Fuel per I. H. P.
	Lbs.
36 Cotton Mills	4·55
4 Wool Mills	9·49
3 Bleach and Dye Works	18·55
4 Printing Works	15·28
2 Tanneries	19·09
2 Paper Mills	13·98
3 Saw Mills	7·29
5 Corn Mills	4·90

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TABLE IV.

Classified List of Mean Coal Consumptions per I. H. P. in 1902 and previous years in 47 Works.

Works and Numbers.	Average First Date.	Gross Coal Consumption per I. H. P.		
		Formerly.	In 1902.	Gain or Loss.
		Lbs.	Lbs.	Lbs.
17 Cotton Spinning Works - -	1889	3·35	3·25	+ 0·10 in 13 years.
10 Weaving Works - - - - -	1884	4·02	3·91	+ 0·11 in 18 years.
8 Spinning and Weaving Works -	1891	3·53	3·67	− 0·14 in 11 years
35 Cotton Mills - - -	1888	3·50	3·52	− 0·02 in 14 years.
4 Wool Mills - - - - -	1884	4·78	3·58	+ 1·20 in 18 years.
2 Silk Mills - - - - - -	1891	6·03	5·25	+ 0·78 in 11 years.
5 Corn Mills - - - - - -	1891	3·72	2·85	+ 0·87 in 11 years.
3 Collieries - - - - - -	1894	8·50	—	—

12762. Table III. deals with 59 works as they were in 1877?—Yes.

12763. And Table IV. deals with 47 works as they were in 1902?—That is so; and not only in 1902, but also at various previous dates in the second column of that table, so that we have three dates. Comparing simply the engines of 1887 with those of 1902 (that is practically 25 years) we find in 1877 there were 36 cotton mills consuming 4·55lbs. of coal per indicated horse power, and now we have 35 cotton mills consuming 3·52lbs. per indicated horse power. There were four wool mills (of course, wool mills use a great deal of steam for boiling purposes) in 1877 using 9·49lbs. per indicated horse power, and at present other wool mills are using 3·58lbs. per indicated horse power. Of course, that could not have been effected simply in the engines; it is also due to improved methods of utilising the waste steam.

12764. And waste heat?—Yes.

12765. In that you refer to such things as Green's Economiser, I presume?—Yes, my Lord. Then the only other cases that I can compare are in the last line of Table III.: There are five flour mills which in 1877 consumed 4·91lbs. per indicated horse power, and now five others consume 3·72lbs., which means a gain of 1·21lbs. in that time. So that one might say there has been a general improvement all round. The last line of Table IV. is of interest as showing how very wasteful collieries are; the consumption per indicated horse power is 8·5lbs.; that is the mean of three collieries.

12766. You are not comparing like with like in these figures. Why, for example, should a silk mill have twice as heavy a consumption as a corn mill; because the steam is used for other purposes than power, is it not?—Yes, that would be so. This is, of course, the gross consumption, and includes all the coal used in the factory.

12767. (*Sir George Armytage.*) All that is used in the mill?—Yes.

12768. (*Sir Lindsay Wood.*) Are they all using the same class of coal?—I should say nowadays they are using far more inferior coal—slack.

12769. I mean in these different works?—One cannot tell.

12770. That would make a very great deal of difference?—Well, I do not think it would make any big difference.

12771. (*Chairman.*) Your point is, as I understand, that in a given district they continue to draw their supplies of coal pretty well from the same resources that they did formerly?—Yes, I should think so.

12772. Although they may use now a larger proportion of slack than they did before?—Yes, and the slack would generally be of a somewhat inferior quality.

12773. But still it is well to bear in mind, as I understand, that you divide the total coal consumption by the indicated horse power of the concern?—Yes.

12774. And therefore, if, for example, as appears from these figures to be likely, the indicated horse power of a corn mill was much higher per 100 tons of coal consumed than that of a silk mill, it makes the silk mill power to be relatively higher per indicated horse power than the corn mill?—That is so.

12775. Because a larger proportion of coal is consumed for other purposes?—Yes, that is so.

12776. You have told us that colliery engines are exceedingly wasteful?—Perhaps I might deal with that point now. Colliery engines are exceedingly wasteful of fuel. In one instance 15 per cent. of all the coal brought to bank is burnt under the pit boilers.

12777. When you speak of colliery engines there, it may be partly the engine and partly the boiler, may it not?—It may be, but it is really the engine that is so very wasteful.

12778. But have they not, some of them, got those old egg-ended boilers at collieries?—They have.

12779. They are rather wasteful?—They are rather wasteful, there is no doubt; but independently of that, with regard to the winding engines, it is difficult to design winding engines that will work economically, because they require to carry the steam for the full stroke; otherwise it is difficult to get the cage to stop at the right level. I understand that improvements are being made at present so that one can use compound * engines and engines worked expansively, but I do not think many of those engines have yet been fitted.

12780. Is electric driving possible in such a case?—I have heard that it is, but I do not know of any case where it has been tried. It ought to be, as we see in the case of lifts where they can stop the cage at the right height; I think it might be applied there with advantage.

12781. (*Sir Lindsay Wood.*) Is not the expansion obtained by the cut off at collieries?—Well, it would be rather dangerous to work in that way, because, supposing the cage does not come quite to the right angle, say a foot or so below the level at which the trucks have

* Explanatory Note sent in by Mr. Stromeyer, 2nd April, 1903.—In my answer to Questions 12779 and 12784, I appear to have omitted the word "condensing" when speaking of compound engines worked expansively, and the subsequent questions show that the Commission were thinking that I was dealing with non-condensing engines. The difficulty I was thinking of was that compound or expansive condensing engines would be difficult to manipulate at the end of a lift, in the same way that it is practically impossible to give a small turn to a compound marine engine.

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Mr. Charles Edmund Stromeyer.

18 Mar. 1903.

to be rolled off, you cannot admit the steam into the cylinder then so as to move the cage another few inches —you will either go up a few yards or not at all.

12782. I know of many collieries where they have to put the steam on at the opposite side of the piston to stop the running of the engine?—Is that in expansion?

12783. Nearly every colliery engine at all modern collieries cuts off on the second or third stroke and runs expansively as to the rest?—Do you mean during the last lift.

12784. No, they put the whole steam on at the lift of the cage; then, when it has got about two or three strokes, they cut off nearly the whole of the steam, or about two-thirds of the steam is cut off, and that brings the cage to the surface. In one case they admit the steam on top, but they stop the cage?—Yes, but there would be difficulty in designing an engine * that would do that conveniently.

12785. They do it.—I believe most of the colliery engines carry the steam for the whole stroke. It is difficult to design a slide valve which will work a full stroke and also cut off at a short stroke.

12786. Well, they do it, certainly.—I do not think there are many. Certainly, at this colliery in particular about which I inquired, they were carrying the steam nearly the whole stroke.

12787. Of course, it is difficult; it is not like a rotary engine that is continually running.—No.

12788. You have to do it to a great extent with the valves which are in your hand—not automatically, but by hand?—Yes. I believe the reason why they have not improved those as much as they might is that fuel is so cheap at the colliery; there has been no great inducement to save. I know of one colliery in which they ask us to design boilers for them every now and then, I should think about three boilers per year. They were always complaining that the more boilers they put down the less work they seemed to be able to do; and finally, we were asked to indicate all their engines for them, and I think we effected a saving of about 30 per cent. for them in pointing out where they could introduce expansion engines and other matters.

12789. In what district was that?—It is near Chesterfield, I think—it is not very far from Sheffield—in that neighbourhood. I have made a comparison showing that in a colliery where they are using 15 per cent. of the fuel brought to bank for the engines, in such a colliery it costs them 1lb. of coal to lift 7lbs. from a depth of about 1,400ft. (I understood that was the depth), whereas, theoretically, they ought to lift 7,000lbs.; and practically, with their improved engines, they ought to lift about 70lbs.

12790. (*Mr. Brace.*) Is that not an extreme and singular case which you are giving?—Well, I am thinking of two cases. We have not made any special inquiries into the matter. Naturally we would get cases laid before us where engines are working uneconomically; they would ask us to inquire into the reasons why they are not doing well. I do not mean to say that all the collieries are working in that way, or even that a large majority are, but I do believe that as a rule they are very wasteful.

12791. (*Sir Lindsay Wood.*) The colliery consumption used for boiler purposes for last year in a colliery I know of was a decimal point within 1 per cent. of the quantity raised, and they were raising a very large output of coal?—I do not think they could improve upon that—not easily.

The obstacles in the way of introducing improvements into land engines are less seriously felt with regard to boilers. There is, however, no advantage in using high-pressure boilers, for they are less efficient than low-pressure ones, because their temperatures are higher, and, consequently, the temperatures of the waste gases are higher. Even in lower-pressure boilers the loss due to the waste gases is considerable, amounting to from 15 to 40 per cent., and various attempts have been made to minimise it.

Amongst these, conomisers occupy the first position; their history is practically that of Green's economisers. The first patent was taken out in 1845, but it was only about 30 years ago that steam users began to look on these steam economisers as forming a necessary part of an installation of Lancashire boilers. According as to whether a boiler is overworked or not, the addition of an economiser will effect a saving of from 10 to 15 per cent. The saving to be effected by the use of an economiser is limited in two directions. Firstly, as economisers are designed only for the heating of water, and not for the generation of steam, and as water evaporates even at considerable pressures when it has taken up about 25 per cent. of the total heat required, it follows that when the combined efficiency of a boiler and an economiser is as high as 80 per cent., the maximum saving due to the economiser cannot exceed 20 per cent. The second limitation results from the humidity of the waste gases. When North Country coals are burnt the waste gases may contain half and even two-thirds of a pound of steam for every pound of coal burnt. When combustion is very good, *i.e.*, when there is a little excess of air in the waste gases, they may thus contain up to 3 per cent. of moisture. When burning water gas, the moisture may amount to 5 or 7 per cent. This moisture condenses on the economiser tubes where the cold water enters them, and, together with the acid, vapours in the waste gases cause very serious corrosion. Boilers which burn anthracite or Welsh coal may be provided with comparatively larger and more efficient economisers, because in that case there would be less moisture and less risk of corrosion. If economisers could be made of a material which will not corrode in the presence of moisture, one could, by introducing the feed where the waste gases are coolest, and, by discharging them where they are hottest, regain nearly all the heat which is now carried up the chimney, provided, firstly, that the boiler alone has such a high efficiency that the waste heat cannot evaporate the economiser water, but will only heat it; and, secondly, that means are provided for producing the necessary draught.

I will now deal with super-heaters. Super-heaters are, apparently, a disadvantage to a boiler, for, on account of the heat abstracted from the partly-cooled waste gases, boilers with super-heaters evaporate less water than do other boilers.

12792 (*Chairman.*) That is to say, they evaporate less weight per ton of coal?—Well, either that way or in the total.

12793. Do you mean proportionate to their size?—Yes, that is so. Supposing you have a boiler that is evaporating, say, 8 lbs. of water per 1 lb. of fuel, and you introduce a super-heater at the back of the boiler, the steam production will sink, and it will very likely come down to 7½lbs. But, of course, the steam is now super-heated, and the heat is not wasted—it has gone into the steam.

12794. Therefore, each pound of steam, as it were, will do more work?—Yes, that is so. The effect of super-heating steam seems to be the same, from an economic point of view, as raising the steam pressure to correspond with the super-heat temperature. Roughly speaking, a saving of steam per indicated horse power of 20 per cent. is accompanied by a decreased evaporation of the boiler of about 10 per cent., and the net gain is about half the gain which shows itself in the engine.

12795. Then a boiler of a given size with a super-heater, according to your view, will raise no more steam than without a super-heater?—It will raise less steam.

12796. But will it develop more power?—It will develop more power; it will develop, practically, as much more power as it evaporates less steam; if the super-heater reduces the evaporation by 10 per cent., the power of the engine will be increased also 10 per cent.

* Explanatory Note sent in by Mr. Stromeyer, 2nd April, 1903.—In my answer to Questions 12779 and 12784, I appear to have omitted the word "condensing" when speaking of compound engines and engines worked expansively, and the subsequent questions show that the Commission were thinking that I was dealing with non-condensing engines. The difficulty I was thinking of was that compound or expansive condensing engines would be difficult to manipulate at the end of a lift, in the same way that it is practically impossible to give a small turn to a compound marine engines

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12797. Because you would say that a boiler, plus economiser, would raise more steam?—It will raise more steam.

Air heaters were introduced for the same purpose as economisers, and have this advantage over them—that the heating surfaces are not subjected to pressure, and that the amount of heat to be recovered is not limited as in the case of economisers. Air-heaters must be made with very large heating surfaces, and as they, therefore, interfere with the natural draft, artificial draught has to be provided. Howden's and Ellis and Eves' systems of forced hot-air draught are the practical result of this idea. At sea these systems are fairly popular, not on account of any appreciable economy, but on account of the increased power to be got out of the boilers fitted with these forced draught systems. I believe, if the inventors were asked, they would say that there is a large gain of economy, but, so far as I can make out, practical engineers consider that it is not the gain in economy, but the gain in weight and space which is the great advantage. Ashore, furnaces supplied with hot air ought to lead to good results; here the advantage would not be the increased power, but the chance of using low-quality fuel. In a recent trial on a refuse destructor, fuel containing only 25 per cent. carbon and much moisture was, with the help of an air-heater, burnt so perfectly that the waste gases contained as much as 12 per cent. carbonic acid, and the temperature of the flame entering the boiler exceeded 1,500° C. Such furnaces might with very great advantage be installed near collieries and in districts where shale and peat are plentiful. I make that suggestion. I believe in those districts where very inferior fuel is to be had the introduction of hot air blasts would be of great advantage. I believe they could burn almost any rubbish.

Mechanical stokers are now used chiefly for the purpose of enabling inferior fuel to be burnt with advantage. They show no economic advantage against hand-firing with good coal, and, as repairs are expensive, steam users frequently find that when the price of slack and other small coal increases, the pecuniary advantage of mechanical stokers disappears. Mechanical stokers are often of great advantage in reducing the smoke nuisance in the case of overworked boilers. The economic importance of smoke is, however, very trifling, as will be seen from the following results obtained during a recent boiler test. When the smoke was absolutely black—as black as it could be made—the heat loss was 0·97 per cent.; when the smoke was black, but daylight seemed to show through it, the loss was 0·22 per cent.; and when the smoke was very light the loss was 0·043.

All previous remarks I have made may be briefly summarised as follows: The increased steam pressures which have become possible through the introduction of mild steel for boilers about 25 years ago have resulted in a considerable saving of fuel at sea, but, ashore steam users are slow to adopt higher pressures. Ashore the most important savings have, apparently, been effected by utilising much of the heat which was formerly wasted. Much still remains to be done in this direction.

12798. Just one question with regard to that last part: Does this point to the conclusion that in your view, with regard to land boilers, the loss due to the higher temperature of the gases where high pressures are used very nearly balances the gain in increased power?—No; I do not consider that the slight loss in the boiler due to the higher temperature can at all be compared with the gain in the engine; the gain in the engine is much greater than the loss in the boiler. But boilers can be worked very uneconomically if the firing is bad; instead of 10 per cent., they can have 40 per cent. of heat loss up the chimney.

12799. And in many cases the coal used for power purposes is only a small proportion, or certainly not more than half the coal used for other purposes?—I should think that is very often the case.

12800. In that case you would think that the high pressures are not economical?—No, they are not.

12801. There is no particular advantage if you want steam for boiling purposes in having it at 200lb. pressure?—No, not generally. I believe that at soap works and some chemical works they actually do want very high temperatures.

12802. For melting purposes?—I do not know what the reasons are, but I know that some of those chemical works do require very high pressures. *Mr. Charles Edmund Stromeyer.* 18 Mar. 1903.

12803. May I ask a question there? You referred to the excess of moisture when you were speaking about the destructor, I think. You spoke of a very low fuel and a very high percentage of moisture?—Yes.

12804. Is the hot air blast of advantage because it evaporates that moisture?—No. It is of advantage because the furnace temperature is so very much hotter.

12805. That is to say, it is not reduced. You get the advantage of the blast without a reduction of the temperature, by reason of the blowing in of hot air?—Yes, that is so.

It has already been pointed out that hot air blasts permit of inferior qualities of fuel being burnt; future improvements in this direction may therefore be considered to result in a saving of better class fuels. A direct saving of fuel may possibly be effected by the more general introduction of producer gas; at any rate it seems to be an established fact that less fuel is required to produce a certain amount of steam if it is first converted into gas than if it is burnt direct in the boiler. This corroborates the conclusion, drawn from a large number of boiler trials, that the average waste of fuel in a boiler is very high, say, 30 to 50 per cent. The cause of this waste is excessive air admission at the furnaces, which is necessary, partly on account of the smoke nuisance, partly on account of the wear and tear of the boiler.

It has just been shown that the maximum heat loss due to smoke is about 1 per cent. Most inventions for the removal of this smoke consist in arrangements for admitting air, resulting in further reductions of efficiency amounting to from 20 to 30 per cent. When smokeless coals are used, and the conditions of firing are as perfect as can be, furnace temperatures approaching 5,000 Fah. could be attained. In the Transactions of the Institute of Naval Architects, 1902, Vol. XLIV., I have shown that such excessive temperatures must produce very severe stresses, both in furnace plates and in water tubes, and such intense heats must increase the wear and tear of a boiler, and are, therefore, not desirable. A solution to this difficulty seems accidentally to have been hit upon, when, for totally different reasons, the Admiralty sub-divided their Belleville boiler by adding a so-called economiser. The essential point of the alteration is, however, not the economiser, but the addition of a second combustion chamber, yet in spite of the principle of double combustion being but imperfectly carried out, in that case the economic results are said to be exceedingly good.

The principle of double combustion in a boiler is as follows:—The bed of fuel should be thick, so that much combustible gas is produced. No air should be admitted over the bed of fuel; the gases, which have an initial temperature of about 2,500° Fah., should be passed over a portion of the heating surface of the boiler until they have been cooled down to, say, 600° or 800° Fah. Additional air should then be admitted, and the gases re-ignited; the temperature would again rise to about 2,500° Fah., and they are then passed over the remainder of the heating surface. We may say that, instead of a maximum temperature of 5,000 F., as with perfect simple combustion, we have 2,500° Fah.—that is, just about half. The strains referred to above are hereby reduced by 75 per cent.; that is to one quarter of what they would be with perfect single combustion. Another point of view is that, instead of a low temperature and much excess air accompanied by a large waste of heat, amounting to, say, 40 per cent., we have a perfect combustion with a minimum amount of air, and, consequently, a minimum, say, 10 per cent., waste heat. It is evident that this double combustion represents a gas producer and gas furnace combined, except that the heat generated in the furnace is not wasted, but is utilised for generating steam. The designers of gas producers are fully aware of the seriousness of this loss, and partially reduce it by blowing steam into the producer. Without this steam, one would obtain a gas consisting almost exclusively of nitrogen and carbonic oxide, and its temperature would be so high that over 30 per cent. of the available heat in the fuel would be wasted during the cooling process. The effect of introducing steam is to

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Mr. Charles Edmund Stromeyer.

18 Mar. 1903.

lower the temperature of the escaping gases by utilising about one-third of the heat for the chemical splitting up of the steam. This heat is regained in the furnaces, but the evaporation of the water has naturally to be paid for, and is certainly not a negligible quantity. My views on combustion and on heat losses of boilers are contained in the memorandum of 1902, which I have handed to the Commission.

12806. Then your view is, that although black smoke may be very objectionable from many points of view, it is not a serious loss of heating power?—Yes, that is so. These experiments were made in the case of a coal dust fired boiler in which the smoke production could be altered at will or stopped entirely; we absorbed the gases from the flue as fast as we could draw them, and we passed them through tubes containing cotton wool; those tubes were weighed before and after the experiment, and the gases were analysd.

12807. Then when you speak of the Belleville boiler, you describe the improvement effected by reason of the reduction of temperature?—I consider that has been the effect of this improvement.

12808. With these very high temperatures do the expansion and contraction due to heating and cooling affect the boilers?—I do not think they would affect the water tube boilers so much as the Lancashire boilers; but the stresses to which I refer are the stresses due to the difference of temperature on the one side and on the other side of the boiler plates. I have shown in the Transactions of the Naval Architects that, for instance, the furnace of a Lancashire boiler of 3ft. in diameter, if it were free to take what shape it liked, would grow 2in. oval, if subjected to this enormous temperature; that is, the bed of fuel would be at about half the height of the furnace; and, if you assume that the furnace was cut through at the level of the fire bars, and that heat were passing through the plate into the water, the fire side of the plate would be hotter than the water side, and would naturally expand, and the top half of the furnace would uncurl and flatten out; but as it is connected to the furnace bottom, it will carry it with it, and instead of expanding as much as it would do if severed at the fire line, it would only expand half that amount, and the final result would be that the furnace, which should originally be perfectly round, would be 2in. oval. It is simply a mathematical calculation, and in practice it does not occur, because these furnaces are always stiffened by rings and end plates; but the tendency to become oval exists, and of course, as the furnaces are held in position, there must always be strains.

12809. The strain would be there, even although the plate is held in position?—Yes, it would be there; and in the case of water tube boilers, I have shown that if the metal is made very thick, the outside of the tube is very much hotter than the inside of the tube; therefore, the outside of the tube would tend to elongate, whereas the inside of the tube remains short; and that would produce very severe stresses in the tube. The conclusion to be drawn from that investigation is that in order to reduce these stresses to a minimum, water tubes ought to be made as thin as possible; but when the tubes are made thin, of course the steam pressure produces stresses, and they have to be made thick, so that there is a mean thickness.

12810. (*Sir Lindsay Wood.*) Do you consider there is much economy in using a better class of coal rather than the inferior classes of coal in your boilers?—That is rather a large question, if it includes the question of price.

12811. No, I meant irrespective of price?—Well, you would certainly use more inferior coal than you would better coal.

12812. These tables which you give us are for 1877, and are compared with 1902. Can you say whether the class of coal used at both those dates was actually the same?—I could not say.

12813. That might affect the results of these figures?—But I do not think it would affect them more than perhaps 10 per cent.

12814. You think you would not get more than 10 per cent. difference between an inferior coal mixed with a large quantity of shale and the best screened coal?—I think that the very best coal is used for very special purposes; for instance, the best Welsh steam coal is all used for steamers, and much of the best north country coal is used for that purpose; and I think that factories get a fairly good medium quality. But nowadays they also use a very large quantity of small coal which is not necessarily bad coal; it is simply so small that it must be burnt by the help of mechanical stokers.

12815. Yes, but would it produce the same quantity of steam?—It should produce practically the same quantity.

12816. That is to say, per 1lb. of coal?—Per 1lb. of coal. The inventors of these mechanical stokers claim that it will do more.

12817. With the introduction of mechanical stokers?—Yes. Of course it would not be economical to burn that small coal without some contrivance.

12818. Then what is the reason the manufacturers pay so much less price for the inferior coal than they do for the best?—They are not in love with mechanical stokers; most people who have had experience with mechanical stokers do not like them.

12819. Supposing they take it by hand, not with mechanical stokers?—It is very difficult to fire a small coal by hand; you do not get good results if it is fired by hand.

12820. I only wanted to see whether you knew whether the two classes of coal which you compare were in both cases relatively the same?—I should say, roughly speaking, they may be the same. Perhaps nowadays they are slightly inferior to what they were formerly, because formerly there were not so many good mechanical stokers as there are now, and small coal is used more frequently now than in former days.

12821. Then the saving, taking that into consideration, would have been rather more than your figures show?—Yes, I think it would be.

12822. (*Chairman.*) I think there can be no doubt, can there, in regard to the 25 years represented that a factory uses what we should call a cheaper coal to-day than it did 25 years ago?—I should think so.

12823. There was not as much competition then, and I can remember perfectly well that we used to get a great deal better coal at the same price per ton, and the whole tendency is to keep down the price per ton?—Yes.

12824. I should have thought that the coal used now in a factory, so far as the coal itself was concerned, was not as good as it was 25 years ago?—I should think that would be so.

12825. And therefore the gain, as Sir Lindsay Wood points out, would have been greater if you actually compared the same coal?—I fancy that would be the case.

12826. (*Sir Lindsay Wood.*) Then you say that colliery engines are exceedingly wasteful of fuel, and one instance you give is that 15 per cent. of all the coal brought to bank is burnt under the pit's boilers. Does that mean the boilers which are used solely for the purpose of raising the coal?—No, all the boilers. In that case there was only screening and tipping the coal into the wagons; there was no coking.

12827. This is under the boilers, you say?—Yes, under the boilers.

12828. I mean a colliery might use 80 per cent. of its coal for various purposes and yet not be uneconomical?—Yes. There were no special purposes here beyond winding and screening the coal.

12829. So that it depends upon what work was done; if the work was simply raising the coal, then it would be a very large consumption, but if they were doing underground haulage, or other work, there is no comparison?—No, but they were not doing very much more than hauling and winding.

12830. Then you say also that there is no advantage in using high pressure boilers?—It is in this way: high pressure boilers themselves are not more economical than low pressure boilers: in fact, they are less economical, because the temperature of the high pressure boiler is higher than the temperature of the low

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pressure boiler, and therefore the waste gases must be higher, and the radiation is also greater; so that the losses from a high pressure boiler must necessarily be greater than from a low pressure boiler.

12831. That is to say, per boiler?—Yes.

12832. But would you recommend high pressure steam?—By all means, because the saving in the engine is very much greater.

12833. And, although there is a loss in the boiler, you get a saving in the actual use of the steam?——Yes. Then modern boilers are nearly always accompanied by economisers, and the efficiency of the boiler does not really matter; what you waste in the boiler is regained in the economiser.

12834. By using the steam through heat?—Yes, the waste gases.

12835. (*Chairman.*) That rather points in the direction that the higher the pressure the more need there is, from an economical point of view, of an economiser?—Yes, that is so.

12836. (*Dr. Le Neve Foster.*) In Table 1, which I have before me, you have gross and net coal consumption per indicated horse-power of factory engines in 1877. Would that be per indicated horse-power per hour?—Per indicated horse-power per hour.

12837. Then what is meant by "gross and net coal consumption." I do not quite understand that?—The gross consumption is the coal used in the boilers which supply steam to the engines and under the boiler which supplies steam for boiling purposes and heating purposes. Of course, that return can only be made in factories where the two sets of boilers are separated.

12838. Then, this table relates solely to factories where they were using steam for two purposes?—Yes.

12839. For driving engines and for boiling?—Yes.

12840. Did I understand you to say you were unaware of the use of electric winding engines?—I am not aware of them; I mean I do not know of any cases.

12841. They are in use. I should like to ask you whether you are in favour for steam-raising purposes of having a chimney or having fans for the purpose of getting a draught?—It is difficult to say.

12842. Is not the tendency nowadays of many engineers to advocate the use of a fan instead of a chimney for getting a draught?—Well, a fan is a necessary evil if you reduce the temperature of your waste gases; for instance, for the purpose of economising heat you might pass the gases through an economiser, extract as much heat here as you can, and then pass them through an air heater, and then practically there would not be any heat left in the waste gases, and you must have some means of producing a draught. So you have a very high efficiency for the boiler, but you have to expend some steam in drawing the gases through the boiler and the economiser and air heater.

12843. But taking the amount of money expended in erecting a large chimney and keeping the fan going, does not the advantage come out on the side of the fan?—I should think it might do so.

12844. You have not gone into that point?—I have not.

12845. Is that not a point that is being a good deal considered now by engineers?—Yes, but it is very difficult to arrive at definite conclusions. The heating arrangements—the economical arrangements—are never quite perfect; people do not quite get the economy which they expect and these ideas have to be worked out in practice for a few years first.

12846. Have they not been worked out practically a good deal already?—The only one that has been before the public for a long time is Howden's forced draught; that is used very largely at sea. The idea there is to economise as much as possible by heating the escaping gases, and then naturally those gases must be driven out of the chimney by means of fans.

12847. With a hot air blast you say you can burn a very inferior fuel. Could you burn a coal with 15 to 20 per cent. of carbon in it?—I should think so, quite easily.

12848. Or, to put it the other way, could you burn a dirt with 15 per cent. of carbon in it?—In the case of this destructor we had about 25 per cent. of carbon.

12849. That was the house rubbish?—Yes.

12850. I mean with this hot air blast you could utilise the very, very inferior kinds of fuel?—I should think so, certainly. I certainly do not think you can imagine a worse fuel than refuse.

12851. And, of course, it is being burnt on the spot close to the colliery?—Yes.

12852. You say in your statement: "A direct saving of fuel may possibly be effected by the more general introduction of producer gas; at any rate, it seems to be an established fact that less fuel is required to produce a certain amount of steam, if it is first converted into gas, than if it is burnt direct in the boiler." Would it not be an advantage if you have producer gas to utilise that producer gas in a gas engine and not to burn it under a steam boiler?—That may be. But you do require steam for a good many purposes.

12853. But if you are simply requiring power, would it not be an advantage?—Yes, I should think that the modern improvements in gas engines will make that system cheaper than first converting it into steam.

12854. But for many purposes the steam boilers do—for many works?—Yes, but there is room for improvements.

12855. If one can get the power by the gas engine instead of by the steam engine, would it not be a good thing to do away with the steam boiler altogether?—Yes, but I am not quite sure that if one adopted every improvement so as to get the highest efficiency possible, there would be very much difference between a gas engine and a steam engine; I do not think there would be very much; and all the manufacturers of this country have already got steam engines and boilers, and if the gain is not very considerable I do not think they would consider it advisable to throw them out. For new factories it might be perhaps the better plan.

12856. Could you tell us anything about firing with coal dust?—I have made one trial on that subject, but I have sent the report to the coal dust people and I do not know that they wish it to be published.

12857. Then I will not ask you anything further upon it?—I may say that the combustion of coal dust is very effective.

12858. Does it answer commercially?—I do not know about that yet. It was tried under a boiler which was not the customary one.

12859. (*Chairman.*) What do you mean by "effective"—that the combustion is complete?—Yes, practically complete.

12860. It does not make smoke?—That is so. It could make smoke and could be smokeless; in fact, the smoke tests I mentioned were made on that furnace, as it was the best furnace on which I could make them, because the coal dust could be fed in quite regularly. I could depend on getting a steady black smoke—or a medium smoke or no smoke—by altering the damper I could regulate the quantity of air and the amount of smoke.

12861. (*Dr Le Neve Foster.*) But do you think there is a future for that?—I think the idea is about 30 years old; I think Crampton had the idea first.

12862. Yes.—But it has never led to anything.

12863. (*Sir George Armytage.*) How was the coal dust supplied to the boiler—under pressure?—It was blown in, I think.

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TWENTY-FIRST DAY.

Thursday, 19th March 1903.

PRESENT:

The CHAIRMAN.

Sir GEORGE ARMYTAGE.
Mr. BRACE.
Mr. BRIGGS.
Professor DIXON.
Dr. LE NEVE FOSTER.

Professor HULL.
Professor LAPWORTH
Mr. MACLAY.
Mr. SOPWITH.
Mr. YOUNG.

The Secretary.
The Assistant Secretary

Mr. WILLIAM JOHN CROSSLEY, called; and Examined.

Mr. William John Crossley.

19 Mar. 1903.

12864. (*Chairman.*) You are connected with the firm of Messrs. Crossley Brothers, Ltd., "Otto" Gas Engine Works, Openshaw, Manchester?—Yes. My firm have used gas as a motive power since the building of these works in 1882; the whole of our premises have therefore been driven by producer gas, used in gas engines, for over 20 years. It has been difficult to make absolute tests of the amount of fuel consumed per horse-power per hour, because of the continual variation in the load upon, say, 12 engines, but after carefully comparing our coal bill with what appeared to be the average indicated horse-power, we have come to the conclusion that, year in and year out, the consumption does not exceed 1lb. of anthracite coal per indicated horse-power per hour. Probably it is considerably less than this amount, but a certain amount of coke has to be added to this figure to provide for the steam used in this plant. The gas plant itself was made by Messrs. Dowson, and has given the utmost satisfaction. It has sometimes run continuously for two years without being touched, the fires never going out. We also use now a gas plant made to the specification of Dr. Mond, with added improvements of our own, which is run with bituminous coal, and which works equally well. It has been most difficult to get actual tests of the consumption of coal in the many plants we have put down, but in several experimental plants used at these works we have got the consumption down as low as ·68 of a lb., ·7 and upwards to 1lb. of coal per b.h.p. per hour, and in a recent test we have just concluded, with an engine of 250 h.p. on a run of 48 hours, we have succeeded in giving current at the cost of 1·3 to 1·4 lbs. of very poor anthracite coal per Board of Trade unit; or, say, ·9 of a lb. per brake h.p., or ·79 per indicated h.p. A most careful test was made by Mr. Langdon, Engineer to the Midland Railway, as to the cost of working the electric light on the Midland Station at Leicester with our engines. In his paper, which is published by the Institution of Mechanical Engineers (Proceedings, October, 1898), it is stated that the cost of fuel was ·13d. to ·14d. per Board of Trade unit for the year. The producers were the Dowson make, and the engines were ours. As he would probably pay about 22s. for his fuel, this would mean that he used 1·19lbs. of coal, year in and year out, for producing this power, and that would be equal to about ·8 of a lb. per b.h.p., or ·7 per indicated h.p. per hour. By these figures it will be seen that the production of power from fuel can be obtained much more economically by converting the coal into gas, and using it in gas engines, than by any other means. An indicated h.p. is equal to 2,545 British thermal units, and to obtain a horse-power indicated in a gas engine requires about 8,500 British thermal units to be burnt in the engine per hour. I believe I am right in stating that steam engines require from two to 20 times this number of thermal units to give the same results. With suitable producers a common kind of bituminous slack can be used to make this gas, instead of using the more expensive anthracite. Such a slack can be bought from 4s. 9d.—I find that price has gone down—upwards, according to the distance of the plant from a suitable colliery. The loss of heat in converting the fuel into gas I estimate at something like 20 to 30 per cent. leaving 70 to 80 per cent. available. I assume 12,000 heat units per lb. of this slack. The loss in the producer would be 3,600 units, leaving 8,400 for use in the engine. The loss in the engine might be taken at 70 per cent., leaving 30 per cent., or 2,520 heat units, to be used, and this corresponds to an indicated h.p. My company can guarantee the effective production of a horse-power for a consumption of ·875 to 1lb. of coal used in the producer per b.h.p., or ·8 to ·9lb. per indicated h.p., according to the quality of the coal, the size of the producer, and other conditions. Thousands of horse-power are blown away to waste by the non-utilisation of the gas coming from coke ovens, blast furnaces, etc.; much is burnt under steam boilers, but quite three-fourths would be saved if burnt in gas engines as compared with steam boilers. Or, in other words, the blast furnace gas now burnt under steam boilers would give more than four times the power obtained if burnt in gas engines; probably much more, owing to carbon deposit on plates and heat of escaping gases. Using ordinary quality of town's gas, the unit of electricity can be obtained from 20·5 cubic feet of gas, by using it in a good modern gas engine, and this, if used to drive a dynamo—the gas costing 2s. per 1,000 cubic feet—would give current for a cost of fuel of ·49d. per horse-power per hour. Good progress is now being made, both in England and on the Continent, in the development of gas producers, both for large powers with bituminous coal and for small powers with anthracite and coke. Much benefit must accrue to the country by the prevention of smoke as well as the saving of coal.

12865. I think there are only two or three questions I want to put to you. I see you speak of anthracite coal?—Yes, my Lord.

12866. Does anthracite coal do better for gas than bituminous?—Anthracite coal contains practically no tar. The difficulty in using bituminous coal has, up to the last two or three years, been in the elimination of the tar.

12867. That being an advantage in the producer——?—You can have a much simpler producer if you use anthracite coal, but for the last two or three years we have been able to grapple with the tar and turn out quite clean gas.

12868. Otherwise the coal contains all the qualities you want?—Yes, it contains all the qualities we want, but we do not want the tar.

12869. At the same time, under the system of Dr. Mond which you have described with your own improvements added, you can use bituminous coal quite well?—We are now using bituminous coal quite well, but up to about five years ago there was a great difficulty in getting rid of the tar. That has now been done.

12870. You mean to say you get rid of the tar in the course of production?—We get rid of it in the course of production, because it clogs the engines.

12871. Subject to that difficulty being overcome, do you consider bituminous coal is cheaper than anthra-

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cite?—Yes. I do not know that bituminous coal is cheaper than coal at the pit mouth, but anthracite in this country is found chiefly in South Wales, and the carriage on it is 8s. or 10s. to Manchester, say.

12872. Therefore you use your Lancashire coal rather than the South Wales coal—you get your coal, I will not say at half the price, but at considerably less price?—We can get coal now for 7s. 6d. per ton, while it costs us 26s. to get anthracite to Manchester.

12873. Do you get as much out of the cheaper coal?—Not quite, because the anthracite is almost pure carbon.

12874. But you get more relatively to the price paid—you get more per £1 sterling?—Yes, nearly three times.

12875. You speak of 250 h.p. engines. Is that the largest you have been able to make experiments with?—We have not been able to make experiments with our larger engines; we have engines running up to as much as 500 h.p., but we happened to have this opportunity in South Wales at Burryport, and we got a 48 hours' run for the figures I have been able to give you, and those are absolutely accurate, so far as I can tell.

12876. Is the manufacture of gas engines going on in these larger sizes?—Oh, yes, it is very rapidly increasing.

12877. Are there any electric light works, for example, in this country that you know of that are driven by gas engines?—There is that one at the Midland station, and there is one on the Great Central line. I could give a number of small stations, but I could not give any large station.

12878. I was referring to the big municipal corporations?—No, not yet; they want larger units than up to just lately have been available in gas engines.

12879. First, dealing with the general manufacturer of the country, whose power is perhaps considerable, but not excessive, what would you say is the minimum amount of horse-power which would justify a manufacturer] putting down producer plant in order to use these gas engines?—We put down producer plants for 20 h.p.—small anthracite plants. They are being put down largely on the Continent for 10 h.p., and they are doing a much larger business on the Continent on account of the Government regulations as to the size of boilers.

12880. But I thought on the ground of economy it was important to recover the bye-products, and for that purpose it was necessary to have plant of some considerable size?—It is not worth while to recover the bye-products in the shape of sulphate of ammonia unless you have 5,000 h.p. I am not a maker of that kind of plant, but the makers say so, and they will not offer a plant, as I understand, to recover sulphate of ammonia under 3,000 h.p.—it would not be worth while.

12881. That is a valuable bye-product, which may be recovered?—It becomes a most valuable bye-product when you are able to recover it in large quantities like that; but for small gas engines it pays very well to go down to 20 h.p., as compared with coal gas.

12882. Therefore your point, put shortly, is this—that although the economy is greater with the use of a large producer plant which enables the recovery of the sulphate of ammonia, you are still of opinion that your figures of relative costs of gas and steam engines hold good, even with regard to the smaller plant?—Yes; the figures I gave you are absolutely accurate. I have not gone into recovery at all; if you go into recovery, you get your coal almost for nothing; if sulphate of ammonia can be sold at something like £12 per ton, your coal bill will be almost blotted out.

12883. I am not sure that I rightly understand the figures, but they seem to me to be quite remarkable, because, according to your statement, you work with a number of British thermal units so much less than you understand that the steam engines require, that it represents anywhere between 50 per cent. and 5 per cent. of the cost of steam?—Yes; that is so. We can work for half the coal the very best modern steam engine requires; there is no doubt about that; we have done it for 20 years.

12884. Of course, there may be some fallacy in that which I do not understand; that is to say, the percentage of reduction in the number of British thermal units may not carry with it the corresponding reduction in pounds sterling?—I think it does. The fallacy in it lies in the cost of the anthracite. As I said, it is only of recent years that we have been able to use bituminous coal. Now, if you take anthracite in Manchester, costing, say, 26s. per ton, there is really not so much advantage as compared with burning common coal under a boiler at 7s. 6d. a ton, because one would equal the other in price, although in the latter case you might use three times the amount of coal. If you pay 7s. 6d. per ton for common coal and 26s. for anthracite, it does not matter if you burn three times the amount of common coal, and that is the reason that in the North the use has not spread so rapidly, although it has spread very considerably.

12885. (*Professor Dixon.*) What is the largest gas engine you are making now?—We have made up to 500 h.p., but we are prepared to go to any power.

12886. 500 h.p. is the biggest?—500 h.p. is the biggest that we have actually made.

12887. You are making a bigger one now, are you?—No; I cannot say that we have one in hand just at the moment; we have half a dozen of 500 h.p. running.

12888. With what gas are those used?—Four of them are used with Dr. Mond's gas, two of them are used with Dowson gas.

12889. The Mond gas is stronger than the Dowson gas, is it not?—I do not think there is much difference. Dowson gas is, I think, a little the better of the two.

12890. Are you sending in steam in the Dowson?—Yes; the Dowson is always sending steam in.

12891. There is more steam now used in the Dowson gas than there was originally, is there not?—Yes; I think we can use more steam. We have improved it so as to be able to use more steam.

12892. Yes; that is the point. Mond gas is pretty well saturated with steam, I think?—Well, Mond puts in far more steam than is needed to make gas, but his steam is put in with the object of making sulphate of ammonia.

12893. Yes; getting the ammonia undecomposed?—Yes.

12894. How long have you been running a Mond gas plant?—Three years, I think.

12895. Has that been pretty continuous work?—Yes; constantly going.

12896. Have you not had trouble with it?—We had great trouble until we found out how to get rid of the tar, but by a patent of our own we get rid of the tar, and now we get it perfectly clean.

12897. You have added that to the original process?—Yes.

12898. (*Chairman.*) I should like to ask you this, for my own information: You say you have got rid of the tar; do you mean you have found some plan of taking it out, or that you have found some plan of overcoming the difficulty, notwithstanding that the tar is left in?—We have found a plan of taking the tar entirely out of the gas.

12899. (*Professor Dixon.*) Then do I understand that you are using all kinds of coal with Mond plant?—No; you must select your coal; you cannot use what is called caking coal.

12900. No; I meant apart from caking coal?—Apart from caking coal, you only want a good bituminous coal.

12901. You have got that from various sources?—We have tried various sources.

12902. You have not had difficulty in burning Lancashire coal?—We always analyse our coal before we use it, and we do not use a coal that will not suit us.

12903. You have had some experience, which enables you to say which coal is best?—If you use a caking coal it bridges in the furnace.

12904. I quite understand that; but of the non-caking variety there are some that work better than others?—Yes; just so.

12905. When you began, did you use Nottingham coal?—Yes; we prefer the Nottingham coal.

12906. Is there a considerable percentage of Lancashire coal of the non-caking kind?—Yes; I think so. We have used Bradford coal and others—I mean from Bradford, Manchester.

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Mr. William JohnCrossley.

19 Mar. 1903.

12907. Are you now using a mixture of those coals?—We have settled down to using one of the Nottingham coals, which we get cheap, and which is very suitable.

12908. You are using Nottingham coal entirely?—Entirely; coal from the neighbourhood of Linby.

12909. Then the gases which you make for working on your premises are now mixed, I understand—both Mond and Dowson?—Well, our Dowson producer was not able to supply us, and the Mond is not quite able to, so that we mix both of them in one holder, but they are both of the same quality.

12910. There is not much difference?—Practically none.

12911. Have you had analyses made of the gases?—Yes; we analyse them every day nearly.

12912. I mean analyses of the separate gases, before they go to the holder?—Oh, yes.

12913. Can you give us those analyses?—Yes; I can send them to you. I have not them with me.*

12914. (*Dr. Le Neve Foster.*) What are the largest gas engines worked at mines for winding or for pumping, or for any other purpose?—I do not think we have any winding engine; I am not aware of any.

12915. Did you not supply a winding engine to the gypsum people in Sussex?—That may be; but I am afraid I cannot remember.

12916. I have seen it at work there?—Yes, I think that is very likely; but I mean, not for coal mines, because gas engines do not lend themselves to the nice starting and stopping that are required for hoisting in coal mines; you want to be able to start very gently, and stop just at the right spot, and restart and reverse, and gas engines have not yet been made to do that.

12917. (*Sir George Armytage.*) I understand there is a jerk?—Yes; there is that sort of difficulty about them.

12918. You want to begin slowly and stop slowly?—That is so; and the reversing is the chief trouble.

12919. (*Dr Le Neve Foster.*) Do you think that difficulty will be overcome?—I think it is likely; but coal mines are the places where they seem not to object to waste coal, and they have got the old simple colliery engines.

12920. How small a plant would be economical for a factory if you were using bituminous coal; you say you can go down to 20 h.p.?—With anthracite.

12921. How low could you go with bituminous coal?—Well, say 100.

12922. (*Mr. Briggs.*) Is the sort of plant that you use for bituminous small, power plant without taking the residuals out; on what principle is that; it is not a Mond plant?—They are all much on the same principle. You have a furnace, and you pass steam and air through the coal, and then you pass it through scrubbers, and clean it. The trouble is that when you have bituminous coal you must have a separator to separate the tar, and that requires power to drive it, whereas the anthracite plant is much more simple.

12923. So that, supposing anyone were wishful of putting down a moderate sized gas plant, say, of 200 or 300 h.p., to generate electricity, a bituminous plant could be very suitably constructed of that kind?—Yes—anything over 100 h.p.

12924. And with anything from 100 h.p. up to 3,000, it is better to leave the sulphate of ammonia alone?—Yes, it is better to leave it alone.

12925. I suppose for a colliery winding it would be easy enough to convert it into electricity—like an electric wind?—Yes, but that would be costly.

12926. It would be costly, but it might not be more costly than steam?—Probably not.

12927. From the point of view of economy?—Yes.

12928. (*Mr. Sopwith.*) I do not know whether you have taken into consideration the question as to the amount of ash that could be used with the fuel. It is rather an important point in this way, perhaps not for the immediate present, but for the future in dealing with the resources of the country as to what coal could be economically used in spite of a large proportion of ash; for instance, we have coals which will contain perhaps as much as 50 per cent. of ash?—Yes.*

12929. As it is at present I take it that you do not care very much if there happens to be 10 per cent. or even 15 per cent. of ash?—Oh, no; we often have 15 per cent. of ash.

12930. In the coal you are using at the present time?—Well, I would not say in that coal, but I have come across that percentage.

12931. It is not a serious consideration with regard to economy; I mean to say you prefer clean coal, but it is not a serious matter, I understand?—If your coal is known to contain a large percentage of ash, the price at which you buy it must represent that. The ash does not hurt the producer; it is a question of getting rid of it.

12932. With these small gas producers would you still say that you could put down economically a producer for bituminous coal of, say, 100 h.p., supposing the requirements were intermittent?—Intermittent requirements always cost you more in either steam or gas than the steady requirements, and you would have no less economy in a gas engine with intermittent requirements than in a steam engine—a great deal more so, in fact.

12933. Do you think you could regulate the supply fairly well?—Yes, fairly well.

12934. (*Professor Lapworth.*) I understood from you that the most economical means of obtaining energy out of the coal is to get the gas out of the coal first, and then burn that gas and get the energy from the gas?—Yes.

12935. You can get this gas from very inferior kinds of coal?—Yes, we can.

12936. At the present day there is a large quantity of inferior kinds of coal left in the pit, or wasted, because it does not pay to extract it?—Yes; you mean coals with 80 per cent. of stone and rubbish?

12937. Well, I would not say as much as 80 per cent., but a great deal—there are inferior coals, which it does

*Analysis of Gas taken from a MOND PRODUCER working at Crossley Bros., Ltd., Gas Engine Works:—

		Per cent.
CO_2	=	9·8
O	=	·2
CO	=	18·4
CH_4	=	2·4
H	=	22·8
N by remainder	=	46·4
Total		100·0

This Producer is worked on Crossley's system, not Mond's.

Analysis of Gas taken from a DOWSON PRODUCER working at Crossley Bros., Ltd., Gas Engine Works:—

		Per cent.
CO_2	=	4·4
O	=	·2
CO	=	26·0
CH_4	=	1·2
H	=	15·6
N by remainder		52·6
Total		100·0

* In December 1903, Mr. Crossley wrote as follows:—"Since giving this evidence we have worked with coal with 30 per cent. of ash, and believe we could work with even a worse material, but I desire to give in evidence the fact that we have used coal with 30 per cent. of ash; and that the analysis of gas obtained from such coal is as follows:—

CO_2	- - - -	6 per cent.
CO	- - - -	23 ,,
CH_2	- - - -	1·9 ,,
H	- - - -	14 ,,
N by remainder	- -	55·1 ,,
		100·0

This would give gas of about 145 B.T.U. on the higher scale. We usually work with gas of 150 to 160 B.T.U. higher scale.

I see no reason why under proper conditions coal with 50 per cent. of ash could not be burnt. Having burnt coal of 30 per cent. of ash we think we now see our way to go to 50 per cent. with certain modifications of plant."

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not pay at present to bring to the surface. I put that generally?—Yes.

12938. Those inferior coals can be used in the future by the gas-producing plant, and energy obtained from them?—Yes.

12939. Then may we say that almost all the inferior coals of Great Britain can possibly be used in the future by these gas-producing processes in order to obtain energy?—Well, I would not like to commit myself to a statement of that kind without having made ample experiments. I have not tried that, but I have tried coals with up to 15 per cent. of ash.

12940. But, generally speaking, these inferior coals can be used for obtaining gas?—Well, I would not like to say so; I should say it is very likely, but I have not had experience, and I must not mislead you.

Mr. William John Crossley.
19 Mar. 1903.

12941. I will put it in another way; the slack and the coals which are rarely used nowadays can be used for obtaining gas. You are using inferior coals yourself, you say—you do not use the anthracite, but you use cheap coal?—We have a large plant running now in Birmingham with coal which is being bought, as I understand, at 4s. 9d.

12942. That is to say, you are using inferior coal for making this gas—that is the point?—Yes.

12943. Then, coals which do not pay for working now would possibly pay for working in the future?—I think that is likely.

12944. Then these inferior coals are, to all intents and purposes, a part of the nation's assets?—Yes.

Mr. CARL DELLWIK, called; and Examined.

12945. (*Chairman.*) Will you kindly state your position?—I am a gas engineer, a Member of the Institution of Mechanical Engineers and of the Iron and Steel Institute.

Mr. Carl Dellwik.
19 Mar. 1903.

12946. You are going to give us some evidence, I understand, about water gas?—Yes. Water gas is produced by the decomposition of steam in contact with incandescent fuel. It is composed mainly of hydrogen and carbon-monoxide, and is, therefore, practically all combustible. It has the highest temperature of combustion of any gas commercially available for heating purposes on a large scale. Its calorific power is about 280 B.T.U. per cubic foot, or 2 to 2½ times as much as that of producer gas, and about half that of ordinary coal gas.

The economy and other advantages of gaseous fuel have for a number of years been amply recognised, and the use of gas firing is constantly increasing.

By reason of its high cost of production and the elaborate apparatus required for its manufacture, coal gas is out of the question for application on a large scale for technical purposes. Producer gas, on the contrary, is very extensively used.

In comparison with the latter, water gas possesses the advantages of containing the combustible gases practically undiluted by inert constituents, and of having a very much higher flame temperature. The former of these qualities makes it possible to conduct water gas for long distances through much smaller mains than are required for producer gas. The cost of distributing water gas is, therefore, much less for a given quantity of calorific power. The higher temperature of combustion makes water gas applicable and very economical for a number of purposes for which producer gas is inadequate, as, for instance, for the welding of plate, chains, etc., manufacture of hard-ware, cutlery, etc., brazing, soldering, calcining, and numerous other purposes. The same quality also greatly facilitates a better degree of utilisation of the calorific power of the gas.

It is impossible to give any general data as to the comparative degree of utilisation and consequent economy in the use of water gas, producer gas, or solid fuel, as these vary with each different application, and it is extremely difficult to obtain definite statements of results from manufacturers using water gas.

The economy of production is approximately the same in converting fuel into producer gas and water gas. In each case 65 to 70 per cent. of the calorific value of the fuel may be transferred into the resulting gas. But, as already mentioned, water gas contains this calorific value in a much more concentrated and therefore more valuable form.

Water gas enriched with oil gas has for a number of years been an important factor in the gas industry. In the United States, where the price of oil is low, it is used to such extent that about 75 per cent. of gas manufactured for general distribution is carburetted water gas. In this country the higher cost of the enriching material makes the cost of carburetted water gas, as a rule, higher than the cost of coal gas. For this reason carburetted water gas has been mainly used in coal gas works to meet extra requirements during the cold and dark season.

The developments of the last few years tend to give a different position to water gas in the gas industry for the purpose of producing gas at a lower cost, and to effect a saving in fuel and labour. It has been found that by utilising "blue," that is unenriched water gas, to mix with coal gas under certain conditions, the illuminating power of the mixture is comparatively very little reduced. This is due to the water gas serving as a carrier for benzol and light oil vapours, which would otherwise have to be recovered from the bye-products from the gas works, or in many cases lost.

The effect of such a method on the consumption of fuel may be illustrated by the following computation. A moderate sized gas works, producing, say, 300,000,000 cubic feet of coal gas per annum, would require about 30,000 tons of coal. But assuming, say, 25 per cent. of this quantity to be water gas, there would be consumed only about 22,500 tons of coal, while the proportionate quantity of resulting coke would be reduced by only about 1,150 tons.

This method has been adopted with great success at several gas works in this country, and at a number of works on the Continent. The utilisation of water gas in this manner very materially lessens the cost of production of the gas, so that it can be sold at a lower price, and compete more easily with solid fuel for heating purposes, and with electric light for illuminating.

In further reference to the utility of water gas for industrial and gas works purposes, I beg to submit the enclosed reprint of a paper on "The Manufacture and Application of Water Gas," read by me before the Iron and Steel Institute (1900), together with certain other papers and reports.

12947. You say in the earlier part of your statement: "By reason of its high cost of production, and the elaborate apparatus required for its manufacture, coal gas is out of the question for application on a large sale for technical purposes." What does that mean—that the cost of manufacturing the ordinary coal gas is so high compared with that of water-gas?—Yes. The cost of producing coal gas varies a good deal, but in a good-sized works I should take it to be generally about 1s. to 15d. per 1,000 cubic feet.

12948. That is to say, the cost of producing ordinary coal gas, such as is used for street lighting?—Yes, whereas the water gas under ordinary conditions could be produced for about 3½d., including similar charges as for the coal gas.

12949. What I wanted to elicit was this: turn the question round the other way; you go on later on in your proof to indicate that the cost of the power, whether produced in one way or the other, is pretty much the same. I do not understand that there is any practical difficulty in using coal gas for technical purposes (as you call them) other than that it is a costly method of manufacturing it?—That is the only difficulty.

12950. But it can be used—there is no difficulty in using it?—No, there is no difficulty in using it at all.

12951. You say the cost of distributing water gas is considerably less, because it is possible to conduct water gas for long distances through smaller mains than are required for producer gas?—Yes.

12952. Is that appreciable?—That is because producer gas contains usually about 60 per cent. of inert gas—nitrogen and carbonic acid—so that for the same quantity of heat conveyed in the gas you would have to send out two and

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Mr. Carl Dellwik.

19 Mar. 1903.

a half times as large a quantity in producer gas as when you distribute water gas.

12953. In one case a volume, which we will call X, contains so much larger a percentage of that which you do not want, and which is no use to you?—Precisely.

12954. And yet you have to force it—you have to convey it?—Yes.

12955. You speak of the quantity of calorific power in water gas, and you say that the higher temperature of combustion makes water gas applicable and very economical for a number of purposes. Then you go on to say: "The same quality also greatly facilitates a better degree of utilisation of the calorific power of the gas." Does that mean that you can utilise a larger percentage of its total?—It means this, that if you want to heat an object the quantity of heat that is transferred, let us say from the flame to the object, depends to a certain extent upon the difference in temperature between the flame and the object to be heated. Naturally, if your flame is of a higher temperature, there is a greater difference between the temperature of the flame and the object to be heated than if the temperature is low, consequently there would be a better utilisation.

12956. In fact, the utilisation is facilitated?—Yes.

12957. The transference is made, of course, more quickly, more easily, and more certainly?—Yes.

12958. You say that it is extremely difficult to obtain definite statements of results from manufacturers using water gas. Why should that be difficult to obtain?—I think it is really trade jealousy. If a manufacturer puts in a plant which gives him a considerable saving in fuel or in labour, he is very averse to making those results public for the benefit of competitors.

12959. But are there no results obtainable from the manufacturers of water gas plants as to their own experience?—Yes, there are. In plate welding there is perhaps not so much economy in fuel over the use of coke, but with the same amount of labour you can produce from three to five times as much length of weld per day. For the melting of metals—crucible steel melting, for instance—with coke firing, you use about three times the weight of fuel to the weight of steel melted, whereas with water gas you could do the same work with probably less than one-third the amount of fuel.

12960. Do those proportions or percentages hold good whether expressed in weight of fuel or in £ s. d.?—Yes. The difference would even be greater expressing it in £ s. d., because for melting metals in crucibles you use foundry coke, which is high priced, whereas in using water gas you might use gas coke, which is very much cheaper.

12961. Would you say that water gas for melting purposes is cheaper than electricity?—Yes, I think very much cheaper.

12962. And as quick?—Well, I think so. However, I could not say that definitely.

12963. When you say the developments of the last few years tend to give a different position to water gas in the gas industry for the purpose of producing gas at a lower cost, and to effect a saving of fuel and labour, what does that mean: do "developments" mean developments as regards the applicability of gas for power purposes or developments in the method of dealing with water gas or its manufacture?—It is mainly this: that in later years the gas industry has suffered from a much keener competition from electric lighting than was the case formerly, and also the use of incandescent mantles has perhaps tended to decrease the consumption for lighting purposes, with the result that there has been a considerable development in the use of gas for heating and cooking purposes. In order to increase that consumption it has to be sold as cheaply as possible, and consequently the cost of production must be reduced to the lowest possible limit, and in that way water gas has been applied in very many places, mainly on the Continent, and in some works in Great Britain.

12964. What is the relative position *qud* incandescent mantles or water gas and the ordinary coal gas; does the admixture of water gas lessen the necessity for the mantle?—No, it does not.

12965. Does it improve the illuminating power with a mantle?—Yes, it does.

12966. But it is mainly a matter of cheapening the cost?—Yes, mainly. I do not know that the effect of the introduction of water gas in this way has yet caused any reduction in the selling price of gas. I would not say that; but it would have that tendency finally.

12967. It may have kept the cost of the manufacture down, and therefore enabled the price to be maintained at the lower level?—Yes.

12968. That is your point, as I understand?—Yes.

12969. Whatever the cost of coal is, can gas be produced cheaper in this form than in the form of coal gas?—Oh, yes, much cheaper.

12970. I did not quite follow these figures. You say in your statement: "A moderate-sized gas works, producing, say, 300,000,000 cubic feet of coal gas per annum, would require about 30,000 tons of coal; but assuming 25 per cent. of this quantity to be water gas" (that is, 25 per cent. of the 300,000,000 cubic feet, as I understand) "there would be consumed only 22,500 tons of coal"—that means a saving of 7,500 tons of coal—"whereas the resulting coke would be reduced by only 1,150 tons"; therefore you would save, according to that, 6,000 tons odd in every 30,000 tons?—Yes, that would be the saving in fuel.

12971. That is 20 per cent.?—Yes.

12972. The admixture, therefore, of 25 per cent. of coal gas reduces the quantity of coal required for making the gas by 20 per cent.?—Yes.

12973. (*Mr. Briggs.*) I think there must be some misunderstanding there? Where is the resulting coke? That is not taken into account.—There would be used 1,150 tons for producing the water gas.

12974. That is to say, you would lose as fuel the coke which would be produced by the other 7,500 tons of coal if you carbonised it?—Naturally you would have a smaller amount of coke for sale.

12975. So that we have also to reckon off the coke which you would have made by the larger quantity of coal before you arrive at the net saving in fuel?—Yes, that is very true; but I think most gas works are very well pleased when they have a smaller amount of coke to dispose of.

12976. They can hardly be that; but the price has been very low?—Yes.

12977. And the price may now be raised for the gas works because of the reduction in supply; they may make more money, although they have less coke?—Yes.

12978. But, as a matter of fact, on the question of the saving of fuel to the country, we must take into account that coke, because it would have been sold cheap to someone else?—Yes, that is quite correct. If you look at it in the way of the saving of fuel to the country, and supposing all the coke to be used to advantage in that way, this would represent a portion of the saving. That is quite right.

(*Mr. Briggs.*) Yes, that is what I mean.

(*Chairman.*) As I understand, you would undertake to make the same quantity of gas with 22,500 tons of coal as was formerly made with 30,000 tons of coal, but you would have 1,150 tons of coke less to sell?

(*Mr. Briggs.*) More than that.

12979. (*Professor Dixon.*) You would not have the coke from the other 7,500 tons of coal, because you never would have bought that coal?—In the one case, say it was all coal, there would be about 15,000 tons to sell altogether; in the other case, there would be 11,250 tons, less the 1,150 tons.

(*Chairman.*) About 10,000 tons.

12980. (*Mr. Briggs.*) Yes, about 10,000 tons instead of 15,000?—That is so.

12981. So that you would have 5,000 tons less coke to sell, but you would save 7,500 tons of coal?—Yes. Then, of course, there would be the other bye-products as well.

12982. They would be lost?—Yes, or rather they would not be produced.

12983. (*Sir George Armytage.*) But what would the net calculation of that be in money?—Do you mean the total saving?

12984. Yes?—There would be 7,500 tons less of coal to be bought; that would probably cost (of course, the

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price varies very much), say about 12s. per ton; and there would be 5,000 tons of coke less to be sold. The price of coke varies very much also—I suppose about 10s.—it would cost in the North of England at present 10s. to 12s.

12985. Then the other bye-products are lost?—The bye-products would not have been produced.

12986. What is the value of the bye-products produced out of a ton of coal?—I really could not say that off-hand.

12987. There is not a very large saving, is there?—No; that would not amount to very much.

12988. You mentioned just now, I think, that ordinary coal gas costs about 1s. 6d. per 1,000 cubic feet to produce, and water gas about 3d. Were you taking into account any interest on capital?—No.

12989. (*Professor Dixon.*) You said 1s., I think, for 1,000 cubic feet of coal gas?—Yes; of course, it varies very much—somewhere about 1s. in a fair-sized gasworks.

12990. Put into the holder?—Yes.

12991. (*Sir George Armytage.*) Can this water gas be used for domestic lighting with mantles?—Yes.

12992. And is it used?—It is used in four towns on the Continent in that way—small towns, however.

12993. Is it used in England, do you know?—No, it is not.

12994. There is no reason why it should not be?—Well, there is really no reason why it should not be. There is likely to be an Act with some restrictions on the use of water gas for general distribution, I understand.

12995. In consequence of what?—In consequence of its poisonous qualities.

12996. Does it give a sufficient light for domestic purposes without mantles?—Not without mantles. It is non-luminous without mantles.

12997. (*Professor Dixon.*) What are the largest installations of water gas plant in this country?—Do you mean for gasworks, or for technical purposes?

12998. For either; first for gasworks?—The gasworks are West Bromwich, Ilford, Tipton, Bilston, and Cleethorpes.

12999. All auxiliary?—That is all as auxiliary to the coal gas plant.

13000. Those are all smaller than Beckton, for instance?—They are very much smaller plants, of course, than Beckton.

13001. At Beckton they have rather a large gas plant, have they not?—I beg your pardon, I was thinking of blue water gas. The oil carburetted gas is produced in very many works, and I could not undertake to enumerate those.

13002. Then for technical purposes other than as an auxiliary for coal gas making, what are the largest installations?—The largest installation is at the Cassel Gold Extracting Company in Glasgow. Then there is a large installation at the Leeds Forge Works.

13003. Do you know the Birmingham welding works?—Do you mean Piggott's?

13004. Yes.—Yes, I know of them. I have not seen their water gas plant, but I know they have been using it for many years.

13005. Do you know that they use it also for incandescent lighting on the works?—I did not know that they did so now.

13006. Yes, they have tried it, and they have done it successfully. Would you tell us the particular advantages of the Dellwik process in making water gas, from your point of view?—We produce about twice as much water gas per ton of coke as was done by former methods.

13007. Is this result mainly arrived at by the high temperature of the coke, to start with?—It is arrived at by the different method of working the generator. The water gas process is, of course, an intermittent process; it consists of blowing with air first and afterwards with steam. Now the accepted theory of the combustion of the coke in the generator with air is that, when you blow air through the coke at a high temperature, you produce carbonic oxide (that is, producer gas), and that develops a comparatively small quantity of heat per weight of fuel burnt. But I conceived the idea that by putting a large volume of air through quickly, the time of contact between the oxygen and carbon would not be sufficiently prolonged to reduce the carbonic acid formed into carbonic oxide, and by doing so three times as much heat is developed during the blow for the same quantity of fuel burnt. That has increased the output of water gas to more than double what it was formerly.

13008. What do you do with the producer gas rich in carbonic acid so made?—It is practically not producer gas at all. It is a non-combustible gas. It contains about 16 per cent. to 18 per cent. of carbonic acid out of a possible 21 per cent.

13009. What do you do with it?—Throw it away—it goes into the air.

13010. You do not even make any carbonate out of it?—No.

13011. Of course, you know in many plants the producer gas is burnt in a chamber beyond the coke?—Yes.

13012. And that heated chamber is used to superheat the steam?—Yes, it is used for that or in a carburetted water gas plant for cracking the oil for the purpose of getting the ammonia.

13013. I was only pointing out that the heat of the formation of CO_2 is not wholly lost in other water gas plants?—No. In, for instance, the Lowe water gas plant for making oil carburetted water gas, it is by no manner of means lost; it is utilised very thoroughly there, but by superheating steam you get a very slight utilisation of it.

13014. (*Dr. Le Neve Foster.*) How large are the towns abroad where this water gas has been used for lighting and heating purposes?—You mean the blue water gas?

13015. Yes.—I think Wiborg, in Finland, is the largest; if I am not mistaken it has a population of about 12,000 inhabitants. The other towns are quite small; they are Osterfeld, in Westphalia, Warstein, in Westphalia, and Brummen, in Holland, but they are quite small towns.

13016. What percentage of carbon monoxide does it contain?—There would be about 38 per cent. or 40 per cent.

13017. Do the authorities make no objection?—No.

13018. Do you give the gas any smell artificially?—Yes, it is odorised by mercaptan.

13019. Are you obliged to do that by the authorities?—Well, I do not know if that has been imposed by the authorities, but at any rate it is a thing which should be done, and is done.

13020. In the case of using this water gas at factories, do you advocate that there should be appliances for rescuing persons who are poisoned—compressed oxygen on the spot?—Well, I do not know of any place where that is done; there may be, but I do not think it is done. I think the poisonous quality of the water gas has been very much exaggerated, because if you take producer gas, which is used to such a very great extent, that contains as much carbon monoxide as water gas does.

13021. (*Chairman.*) But there were two cases of poisoning at the Leeds Forge, were there not?—There were, a number of years ago. I think those are the only ones.

13022. (*Dr. Le Neve Foster.*) Therefore you do not think that in the ordinary way anything special is needed in the way of preventing or remedying cases of poisoning?—No, I have never found that necessary.

13023. (*Chairman.*) Do you mean that it would be of no use?—No, I do not mean that, but I mean that there is so little likelihood of its being called for. There are a very great number of works that are using water gas for manufacturing in Germany, and I have never heard of any appliances of that kind being kept there.

13024. (*Dr. Le Neve Foster.*) At Wiborg is there much heating done with it in the houses?—I really could not tell you about that. I have not been there myself, but undoubtedly there is some—probably not very much, because wood is very plentiful in that district.

13025. (*Professor Dixon.*) When water gas is mixed with coal gas does it alter the nature of the combustion of the coal gas; for instance, in the explosion of the coal gas in a gas-engine cylinder? Does it make it

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Mr. Carl Bellwak.

19 Mar. 1903.

harder to use coal gas in gas-engines?—No, there is no alteration to the gas-engine at all. It may consume a very slight quantity more.

13026. I mean owing to the rapidity of combustion?—No, there is no difference in that at all.

13027. You have not detected any?—I have not detected any; in fact, there are several places where gas-engines are used with blue water gas without any admixture of coal gas, and there is no alteration made in those engines except that the gas ports are opened a little bit so as to admit a larger quantity of gas.

13028. Do you mean water gas and air used directly without any coal gas at all?—Yes.

13029. With what size of engine?—Messrs. R. and J. Dempster, in Manchester, have a 40 h.p. engine running; that was built for coal gas about 14 or 15 years ago. Then there are two engines at the Ilford gasworks which are small—one of 8 h.p. and one of 10 h.p., I think.

13030. What make is that gas-engine at Messrs. Dempster's?—That is a Crossley engine.

13031. With an "Otto" cycle?—Yes.

13032. Of course, you know that coal gas cannot be used in these very large gas-engines?—Well, yes, because of course they are built mainly for the use of blast furnace and producer gas.

13033. Yes, because coal gas cannot be used. Is not that one reason?—Yes, and then it comes pretty high in cost as well.

13034. About 40 h.p., then, is the largest engine that you know of ever having been used with water gas?—No; a number of years ago I obtained a list from the German works at Deutz—the "Otto" works—and they had delivered several engines of 50 h.p., and if I am not mistaken, one of 100 h.p.

13035. You do not know whether that is working there, do you?—I do not know whether they are running now, because that was some years ago.

13036. Of course, you know the difficulty is the rapidity of combustion of such a mixture?—Yes, quite so.

13037. It makes such a blow on the piston?—Yes.

13038. (*Mr. Briggs.*) In the cost of ordinary coal gas, which you put at 1s., is that after giving credit for bye-products that are taken out of the gas?—Yes.

13039. I suppose the poisonous character of water gas undoubtedly frightens the local authorities in England very much. They are mostly timid about it, are they not?—Well, I am not sure that it is the local authorities which are as a rule most frightened.

13040. Do you mean it is the gas companies?—Well, no.

13041. Perhaps it is the central authorities?—Yes.

13042. They restrict it, at all events?—It is not restricted now, but I understand there is some probability of a restriction being imposed.

13043. Supposing you were substituting blue water gas for coal gas, would you benzolise it first for use in ordinary flat flames?—You mean using just blue water gas without any admixture of coal gas?

13044. Yes, or supposing you mixed 50 per cent. of water gas and you wish to keep the utilising power, could you do that economically by your plant, and then benzolise it?—Yes, we mix, as a rule, now from 25 per cent. to 30 per cent. of water gas—from that downwards, according to requirements—and we enrich with benzol.

13045. Then do you find the benzol is permanent when it is once put in?—Yes.

13046. And it would carry just as well as the coal gas?—It carries just as well as the coal gas, and I do not know of any case where there has been any condensation in the mains. It has been used for some years at Königsberg, in Prussia, and the climate there is very cold; they seem to have had no difficulty whatever.

13047. Do you get a higher illuminating power originally in your water gas than that in the coal gas, or is it about the same?—That depends upon how much is used, of course.

13048. I mean is it the practice to make it as high as in coal gas?—That varies very much.

13049. I suppose you might have a very high power in coal gas, and you would bring it down?—Yes. There are certain towns in Germany where they are not so strictly bound in regard to illuminating power, and they have been putting in as much as 35 per cent. and even 40 per cent. of blue water gas without any enrichment at all, and then they have had a gas of about 11 or 12 candle power.

13050. To what point of enrichment do you find it practicable to use benzol—we will say you have blue water gas, which is non-illuminant?—Yes.

13051. Can you enrich that gas with benzol so as to carry it say up to 18 candles or 16 candles, or what is convenient?—No, I should not recommend using blue water gas alone benzolised, because then the quantity of benzol would be too great for it to carry. It is only in admixture with coal gas that I would recommend it. When you want to use water gas alone it is far better to carburet with oil.

13052. But benzol being cheap at present, it answers the purpose very well?—It answers the purpose very well, and it is cheaper.

13053. It is cheaper now—less benzol goes instead of a certain quantity of oil, in fact, much less?—Yes.

13054. Then is it your view, as Sir George Livesey said yesterday, that in future the illuminating power of gas could usefully be brought down and cheapened? Do you think that is likely to be the tendency?—I think there is not the slightest doubt that the tendency is that way.

13055. And that the use of mantles with a very much poorer gas will give all that the public requires?—Yes.

13056. And, therefore, the enrichment would not require to be very large in any case with your blue gas?—No.

13057. You would put a certain amount in, but not so much?—Quite so.

13058. (*Mr. Young.*) Is there much difference in the price of the installation for coal gas and water gas?—Yes; the water gas installation is very much cheaper for the same capacity.

13059. Cheaper?—Oh, yes; much cheaper for the same capacity.

13060. Could you say what the cost for interest would be for 1,000 cubic feet in the case of coal gas compared with what it might be in the case of water gas?—I am afraid I should not like to commit myself to a figure, because the cost varies so very much in the case of coal gas, and likewise in the case of water gas; according to whether the gas is used regularly or irregularly—some plants may perhaps work day and night, and in that case the charge for interest would come very low; other plants would perhaps work on one shift of eight hours; and some others may work for half a year, and one or two shifts a day, and perhaps stand idle for the rest of the year.

13061. But what difference there might be would be in favour of water gas, I presume?—Well, whatever difference there is would be in favour of water gas, because of the lower capital required.

13062. (*Mr. Sopwith.*) You said that the cost of distributing water gas is much less for a given quantity of calorific power as compared with producer gas?—Yes.

13063. But when you are talking about the capital, supposing there are very large mains to lay, and a great length of mains to lay, of course you would have to double the capacity of the mains for water gas as compared with coal gas?—Yes, quite so.

13064. Therefore, supposing they were very expensive mains, conveying a very long distance, that would add to the capital as compared with coal?—Yes.

13065. That is very material?—Yes, there is no doubt of that. Perhaps I should explain that in making that statement I did not exactly think of water gas as being distributed for a town; I had in view more the distribution of gas within a large manufacturing establishment, for instance, where you require gas for various furnaces; and with producer gas you would have to

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have very large conduits, whereas with water gas you would have much smaller mains.

13066. You mean to say that the situation is altered if you have to convey your gas from a long distance from what it would be if you were only dealing with distribution within a small radius?—Quite so.

13067. I only mention it upon Mr. Young's question as to capital; it seemed to me you were pointing out that there was a very great advantage with water gas as compared with producer gas, but that would apply equally to water gas as compared with coal gas?—Yes. *Mr. Carl Dellwik.* 19 Mar. 1903.

Dr. EDWARD HOPKINSON, called; and Examined.

13068. (*Chairman.*) What are your qualifications?—I am a member of the Institution of Civil Engineers, a member of the Council of the Institution of Mechanical Engineers, and a member of the Institution of Electrical Engineers, Doctor of Science, and Managing Director of Mather and Platt, Limited. *Dr. Edward Hopkinson.* 19 Mar. 1903.

13069. Will you give us your statement?—The success already attained by many undertakings in America, on the Continent, and in the United Kingdom, formed exclusively for the production and distribution of electric power, and the rapid development of a "Motor" load in many large towns, when the authorised undertakers have originally contemplated electric lighting only, make it appear probable that in the near future a considerable proportion of the power required by small users in towns will be derived from central stations for the supply of electrical energy, and elsewhere, from the large power stations, which are projected in various parts of the country; and also that the latter will attract large users of electric power to their vicinity, as has been proved in the case of Niagara and other large power stations.

Electric power Bills with a total authorised capital of over £14,000,000, for the supply of power over an approximate area of 10,000 square miles, have already received the sanction of Parliament.

All such stations have hitherto been worked by water power or steam power. I purpose to deal with the economy of fuel which may be anticipated from the use of large gas engines, such as are now available in place of steam engines for driving dynamos.

Until quite recently the gas engine had not been sufficiently developed to enable it to be used for driving dynamos of large power; now there are several designs of gas engine of 500 horse-power and upwards, which are being sucessfully used for driving electric generators, for the production of both continuous and alternating currents. The first large gas engines (by "large" meaning 500 horse-power or more) were in general designed for driving blowers, and worked with the waste gases from blast furnaces. I now have personal knowledge of two large iron works in Germany using large gas engines in place of steam engines for driving dynamos for distribution of electric power in the works; of a third, where a recent and up to date steam plant has been discarded in favour of gas engines; of two large chemical works in England which have installed a number of gas engines of 500 horse-power for driving dynamos with producer gas, in place of steam engines; of a third large chemical works in England at the present time the largest producers of electric power in the United Kingdom, which has put down gas-producer plant, and are engaged in replacing most efficient steam-driven dynamos by dynamos driven by gas engines; and of new engineering works in the North which are installing 2,000 horse-power gas engine driven dynamos using producer gas in preference to steam dynamos. In some of these cases the dynamos are for the production of continuous currents, in other cases of alternating currents; but in neither case is difficulty experienced in running the dynamos in parallel; which is a condition essential for economical working in a power station where the load is variable.

In July, 1902, there were 78 gas engines of 500 horse-power and upwards at work or in the course of construction in Europe and America for the purpose of driving dynamos aggregating nearly 53,000 horse-power; at the present time there are gas engines of the "Körting" double acting two-cycle type alone aggregating 68,000 horse-power, of which a large proportion are for driving dynamos.

Consider, as a typical instance, a central station for the production and distribution of electrical energy for power and lighting of 25,000 indicated horse-power, equivalent to an output of 15,000 kilowatts, in the first instance designed as a steam power station. If this be equipped with water-tube boilers for a pressure of 200 lbs. per square inch, with super heaters, high class compound steam engines, driving dynamos direct, complete accessory plant for coal and ash handling, economisers, and condensing plant, I estimate the initial cost at £270,000 or £18 per kilowatt, exclusive of buildings—or including buildings and foundations at £330,000, or £22 per kilowatt.

13070. (*Professor Hull.*) May I ask you what a kilowatt is?—A kilowatt is a unit of power equivalent to one and one-third horse-power; it is the unit universally adopted in electrical measurements; a kilowatt for an hour—that is to say, the power of a kilowatt continued for an hour—is the Board of Trade unit of electrical energy.

13071. (*Chairman.*) You speak of the estimated initial cost for 25,000 indicated horse-power as being £270,000?—Yes.

13072. Roughly that is a little over £10 per indicated horse-power is it?—That is so. Of course, there is this difference, which I may mention now: in speaking of 25,000 indicated horse-power, I mean the power indicated by the engines, and in speaking of kilowatts I mean the electrical power obtained from the dynamos; there is the frictional loss in the engines to be taken into account, and the frictional loss in the dynamos.

13073. (*Professor Dixon.*) Would you say "the brake horse-power"?—The brake horse-power is the power actually obtained from the engine shaft and delivered to the dynamo.

13074. If you say "brake horse-power" instead of "indicated horse-power" you would get a better comparison, would you not?—In that case you should take about 90 per cent. of it. The efficiency of the dynamos will also be about 90 per cent. Taking account of these two factors, and of the change of unit from horse-power to kilowatts, the output of the station in kilowatts will be 60 per cent. of the indicated horse-power.

On a full load test run the coal consumption, expressed in terms of Welsh coal of about 15,000 B.T.U. calorific value, or the equivalent in coals of inferior value, may be taken as 2·5lbs. of coal per kilowatt-hour (or Board of Trade unit) of available electrical energy; or of bituminous Lancashire slack coal of, say, 12,600 B.T.U. calorific value, 3·0lbs. of coal per kilowatt-hour, making allowance for the working of the auxiliary plant, condensation in steam pipes and otherwise.

The actual working conditions are, however, very different from a full load test run. The plant will in general be only partially employed; that is to say, the "load factor" or ratio of the time average of supply to the maximum will be less than unity. Owing to various standing losses and loss of efficiency when not working at full load the load factor has great influence, both on the cost of production and on the fuel consumption. It is quite probable that in a central station, such as the one under consideration, the load factor will be about 25 per cent.; that is to say, the actual time average of the output will be only 25 per cent. of what the maximum output at any particular time is.

13075. (*Chairman.*) It is the equivalent of running for only one-fourth of period at full load?—Yes, so far as output is concerned that is so.

In various town central stations, the motor load factor varies from 24 per cent. to 43 per cent. In well-established electric light stations it varies from 10 per cent. to 20 per cent. In Liverpool, which produces 20,000,000 units per year, half of which is for traction purposes, it is 24·2 per cent. In Bradford, having an output of 5,000,000, of which about a third is for motive power, it is 15·6 per cent.—the motor part being 30 per cent. In Manchester, having an output of 10,000,000 units, before the present traction load was developed, of which about 18 per cent. was for motive power, the load factor was 13·4 per cent.

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Dr. Edward Hopkinson.

19 Mar. 1903.

"The statement of the load factor, taken over a year's working, as is usual, is not in itself a complete specification of the economic conditions of working. Much depends upon how this factor is made up, e.g., a cotton mill, working on an average 50 hours per week throughout the year, has a load factor of 30 per cent., the load not varying during the hours of work; while a tramway system working much longer hours may have the same load factor, the load varying during the hours of work ing over a wide range. The former is much more favourable to economic working than the latter, although the load factor is the same.

13076. That is due to the fact that it is more continuous; it is more uniform during the period of working?—Quite so.

13077. In tramway working large numbers of people move at certain times of the day?—Yes; and a fall of snow would make an enormous difference in the load.

13078. Is the tramway working by means of an overhead trolley?—Yes.

For chemical operations, which are carried on continuously, the local factor will approach unity and the economic conditions will approach what has been described as a test run. In the chemical works which I have already referred to, which are the largest producers of electrical energy in the United Kingdom, they produce about 30,000,000 units a year, compared with the city of Manchester, which produces 10,000,000 units, and Liverpool 20,000,000 units.

13079. (*Professor Dixon.*) But the production of Manchester is much over 10,000,000 now, is it not?—No doubt it is; but there are no public returns for the last few months; still, it will not approach anything like 30,000,000 units.

In the chemical works to which reference has already been made, the actual coal consumption of bituminous Lancashire slack coal is 4·1 lbs. per kilowatt-hour. That 4·1 lbs. is to be contrasted with 2·5 lbs. for Welsh coal, or 3 lbs. of bituminous coal, working under test conditions.

13080. (*Sir George Armytage.*) And the kilowatt-hour is a Board of Trade unit?—Yes.

13081. (*Professor Dixon.*) Is this since the gas engines have been put up?—No; I am referring to steam only throughout.

With a load factor of 25 per cent. I estimate, from actual experience in various places, that the fuel consumption will be 8 lbs. of Lancashire slack coal per kilowatt-hour. That figure is from the actual results at a large number of stations, and I want to contrast that figure of 8 lbs. with the 3 lbs. on the test run as being the effect of the load factor being 25 per cent., instead of unity.

13082. (*Chairman.*) This is your estimate, as I understand you to say, of the cost of producing this amount of electric energy or electric power by the highest form of steam plant?—Yes.

13083. Then we shall get, I suppose, the comparative figure for gas?—Yes.

13084. (*Professor Dixon.*) What do you put the price of that coal at, roughly; have you averaged that?—It varies much from time to time; but I should think in Lancashire the fair average would now be 10s. delivered.

13085. As high as that?—9s. to 10s. perhaps. I may say in the case of the chemical works I have referred to, the actual price delivered there is 7s., but they are in a very favourable location.

13086. (*Chairman.*) Near the coal-pit, you mean?—Well, they are on a canal directly communicating with the coal pits.

13087. (*Professor Lapworth.*) Has the price of slack coal been rising of late years, owing to the increased demand?—No, I could not say so. The price has fallen, of course, very considerably since the high prices of two years ago.

13088. But going back, say, 10 or 15 years—can you go as far back as that?—I am afraid I cannot answer that.

13089. (*Chairman.*) But the relative figures would be the same, whatever the price of coal?—Yes, they would, certainly; in fact, throughout I have kept to 1lb. weight of coal rather than price, the weight of coal being definite and the price not.

13090. (*Professor Dixon.*) It is the same coal you are going to compare with the gas—with regard to generation of power?—Yes.

Secondly, consider a similar station, equipped with gas producers using bituminous coal, and dynamos driven by gas engines. I estimate the initial cost of such a station, including all accessories (a) without ammonia recovery plant, at £19 per K.W., exclusive of buildings; or £22 per K.W., including buildings and foundations.

13091. (*Chairman.*) That is the same, including buildings?—It is substantially the same.

13092. It is exactly the same—£22 per kilowatt. It is £18 without buildings as against £19, but £22 is exactly the same?—Yes, exactly the same. Then (b) with ammonia recovery plant, at £20 per K.W., without buildings, or £23 10s. per K.W., including buildings and foundations.

13093. Then, practically, these figures go to show that the cost of installation is practically the same of gas or steam?—Yes, that is so. I have gone into these figures merely for the purpose of showing that there is no bar to the use of gas plant on account of initial cost.

13094. Quite so.

On a full load test run the consumption of gas will be 115 cubic feet of gas per kilowatt-hour, the gas being of 1,250 calories per cubic metre (equivalent to 140 B.T.U. per cubic foot), and the efficiency of the engine being 2,800 calories (equivalent to 11,200 B.T.U.) per B.H.P. hour. The consumption of bituminous coal in the producers only will be 1·81 lbs. per kilowatt-hour. Allowance must, however, be made for the coal required for the subsidiary pumping and blowing operations, and for raising the steam required in the producers. This will add 0·27 lbs. per kilowatt-hour, making the total coal consumption 2·08 lbs. per kilowatt-hour. That you will observe compares with 3 lbs.

13095. (*Mr. Briggs.*) That is the whole load test run?—The whole load test run.

This result is obtained assuming that half the steam required for the producers is raised independently, and half obtained from the exhaust gases of the engines. No doubt further economies can be realised in respect to this item, as there is theoretically more than enough heat in the exhaust from the gas engines for raising all the steam required for the producers.

There is little data from actual practice for determining the effect of the load factor on producer plant, but as an approximate figure I estimate that if the load factor be 25 per cent. the fuel consumption will increase to 2·8 lbs. per kilowatt-hour. I may perhaps mention that in the case of the Barcelona Tramways, which are worked with gas engines and producer gas, burning anthracite coal, the consumption is there actually 2·2 lbs. per kilowatt-hour. Of course, in burning anthracite coal there is an advantage, and the tramway load factor would be more than 25 per cent. That is one actual case which substantiates my estimate of the 2·8-lbs. Gas plant has great advantages over steam plant in reducing the standing losses. In the case of steam plant, from the boiler flues to the engine cylinders, the temperatures are much higher than from the producer to the gas engine cylinder, and consequently the standing losses from radiation and condensation are greatly reduced. Again, a producer can be almost instantaneously banked by cutting off the blast, and put into operation again with consequently much less loss than in the case of boilers.

13096. (*Chairman.*) Loss in that case being, roughly stated, due to evaporation, to the time occupied in getting up steam, and so on?—Yes.

13097. It is loss of heat?—Yes, the heat disappears, of course, in various ways. I want particularly to contrast the comparison of the figures of a test run, namely, 2·08 lbs. to 3 lbs., with the figures under actual conditions of 25 per cent. of load factor, where the comparison is 2·8lbs. to 8lbs.

13098. I am not quite sure that I follow this. I understand that the figure 2·08 compares with the figure 3 as to coal consumption on the full test load; but what does 2·8 compare with?—It compares with 8 lbs. in the case of steam.

13099. (*Sir George Armytage.*) Then in both cases you are speaking of Lancashire coal?—I am.

13100 (*Mr. Briggs.*) The loss in steam in having a

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load factor of 25 per cent., as compared with a full test load, is so enormously greater that in practical working with a load factor like that, gas becomes nearly three times more favourable than steam?—Yes.

13101. Whereas in the full test there is only 50 per cent. difference?—Yes.

13102. (*Sir George Armytage.*) It is practically one-third?—It is practically one-third. That is really the whole point of my evidence. Of course, the comparison of steam and of gas, on full load tests, has been made repeatedly; but I have not seen before a comparison made where the load factor is taken into account, and the results are certainly very remarkable.

13103. (*Mr. Briggs.*) They are startling?—Yes.

13104. (*Chairman.*) Of course it must be kept in view that this economy is the economy of coal?—Yes.

13105. It does not follow, therefore, that the costs would work out in these proportions?—No, certainly not the total cost; the cost of wages, of oil, and of stores will be very much the same per unit.

13106. And depreciation?—Depreciation would also be very much the same; but then on the other hand, if you consider the financial aspect of it there is the advantage to be gained by the recovery of the sulphate of ammonia.

13107. (*Sir George Armytage.*) You have not taken that into account?—I have not taken that into account, because that is really not a question affecting the coal consumption; it is only a question affecting the financial aspect of the matter.

13108. Yes, but then in estimating your capital charge for the gas plant, have you estimated for the plant that will recover ammonia?—I gave the figure both with and without recovery.

13109. (*Chairman.*) But *qua* coal consumption, the result, as I understand, which you anticipate, would be that 1,000 tons of coal used in the form of gas would give as much work and produce as much power as 3,000 tons of coal used in the form of steam?—Yes, approximately so.

13110. And, therefore, there would be a saving of at least 33 per cent. in the amount of coal consumed?—No, 66 per cent.—a saving of two-thirds; the amount actually used would be about one-third.

Hence it appears that such a central station as has been described, if equipped with gas plant, will involve a capital outlay approximately the same as with steam plant, and that the fuel consumption, if worked at full load continuously, will be reduced in the proportion of 100 to 83, and if with a load factor of 25 per cent., in the proportion of 100 to 35.

These figures only represent the actual saving in fuel. The economy in the money cost of fuel is much greater, owing to the fact that coal can be used in the producers, which can be supplied at less cost than coal for use in steam boilers, proportionately to its calorific value.

13111. That is less cost per ton, I take it, is it not?—Yes.

13112. It is rather a question of price per ton?—Well, it is rather more than that; it is less cost per ton of coal of the same heating value.

13113. (*Sir George Armytage.*) You use an inferior coal?—We use an inferior coal, but the coal is actually cheaper, taking the same calorific value, than the higher class coal.

13114. (*Chairman.*) In other words, that a ton of slack, at 5s. per ton, would contain more power, from your point of view, than a half-ton of the larger coal at 10s.?—Yes. You take these figures of 5s. and 10s.; they may be correct in some parts of the country, but I do not think they would be quite a fair representation with regard to Lancashire.

13115. No, not the relative difference between slack and large coal; I suppose they would represent about five and eight, would they not?—You could not get slack, except at the pit's mouth, at 5s. per ton. I should say that 7s. and 10s. would be a nearer comparison.

13116. In our part of the world we get slack at 5s., certainly?—Delivered at the station.

(*Chairman.*) Yes, in Leeds you can get slack delivered at 5s. per ton.

(*Mr. Briggs.*) The Leeds Corporation are buying coal at much less than that, delivered at their electrical station.

13117. (*Chairman.*) But I gather that your real point is, that coal out of the same seam, which is sold at less money, because it is small, contains relatively *qua* money, more value for the purposes of gas than the large coal?—Yes. *Dr. Edward Hopkinson.* 19 Mar. 1903.

13118. (*Mr. Briggs.*) While you are upon that point, may I ask, when you say "slack," possibly, you are meaning a largish admixture of good-sized pieces with it?—No, I mean really slack.

13119. For really quite fine coal the price of 5s. is the price at about which it is delivered, but if it is what is known as "slack" in mills it would cost more?—These figures vary so much that I have not them in my head, but I know that the particular works which I have mentioned are now paying 6s. 11d. for a good quality of slack delivered at their works.

The economy in the money cost of fuel is much greater, owing to the fact that coal can be used in the producers, which can be supplied at less cost than coal for use in the steam boilers, proportionately to its calorific value, and also to the fact that the recovery of the ammonia may be taken as a direct saving in fuel money cost, equal, in the case of coal used in the producers worth 7s. per ton, to a saving of 4s. 6d. per ton at the present price of ammonia sulphate.

The cost of transmission and distribution of electrical energy, although of great importance from a financial point of view, owing to the considerable cost of cables, and the maintenance of the same, and the cost of wayleaves, is not material to the question of fuel economy, as, taking a maximum radius of supply of 10 miles from the central station, the average loss of transmission, and, where necessary, of conversion from high to low pressure, and re-conversion will not exceed 20 per cent., *i.e.*, the electric energy sold will not be less than 80 per cent. of the electric energy produced at the station. Assuming this figure, and allowing 90 per cent. as the average efficiency of the user's motors, the consumption of fuel, taking the load factor as 25 per cent., will be 11 lbs. per kilowatt-hour, or 8·25 lbs. per available h. p. hour, if supplied from a steam-driven central station, and 3·9 lbs. per kilowatt-hour, or 2·92 lbs. per available h. p. hour, if supplied from a gas-driven central station.

13120. (*Chairman.*) This is the relative cost of electric energy produced by a steam-driven central station and a gas-driven central station?—Yes, of the electric energy actually delivered to the user at a distance from the central station.

13121. Yes, but delivered at an equal distance from both stations by cables?—Yes. Perhaps I may mention here some rather interesting figures, which I only came across a day or two ago, arrived at by a very high authority, Sir Frederick Bramwell, who, at one time, some years ago now, made a careful investigation into the actual fuel consumption of a large number of works around Birmingham; taking an average, he found that they actually burnt 18 lbs. of coal per indicated horse-power hour, which is rather an alarming figure, but it is a figure which, from my own experience, taking the average of individual places, I should quite substantiate.

13122. (*Dr. Le Neve Foster.*) Is that when he was getting out a scheme for the supply of compressed air?—I think it must have been.

13123. In the seventies?—Yes, it was some time ago.

On the basis of Professor Burstall's figures for transmission of gas under pressure, the ultimate fuel consumption will be approximately the same, whether the small user receives his power in the form of producer gas, and himself converts it by small gas engines into available mechanical power, or receives it as electrical power, inasmuch as the heat efficiency of small gas engines is not much less than that of large gas engines; but there can be no doubt that if the user requires energy for power or lighting purposes, and not for heating purposes, the convenience is much greater, and the cost to him much less in the case of electrical distribution.

13124. (*Chairman.*) Professor Burstall, in that connection, gave rather an interesting figure, namely, that more than 60 per cent. of the consumption of coal was for heating purposes, and upon that he largely founded his case for distribution by means of gas. Do you agree with that?—I do. Of course, that would vary very much indeed in different localities.

13125. Oh, it was an ordinary industrial town, I suppose, "60 per cent. of the total coal was used for heating

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Dr. Edward Hopkinson.
19 Mar. 1903.

purposes, leaving 40 per cent. for lighting and power." His point was that lighting and power could be conveniently, and, perhaps, equally conveniently distributed, by means of electric cables, but that, inasmuch as 60 per cent. of it was for heating purposes, that could not be distributed by electric cables, but could be distributed in the form of gas.

(*Professor Dixon.*) For kitchen fires?

(*Chairman.*) Yes, in stoves, and so on.

(*Witness.*) I think he would have in mind a district where there were a large number of heating furnaces for metallurgical operations of some sort.

(*Chairman.*) I think not—at least, I do not think that was the way in which he put it; I think he put it as in ordinary industrial towns.

(*Sir George Armytage.*) I do not think that question as to whether the fuel consumption would be more or less in electricity than in gas was quite clearly brought out.

13126. (*Dr. Le Neve Foster.*) It must make a difference whether you have cotton mills or metallurgical works?—Yes, an enormous difference.

13127. (*Chairman.*) Well, no, the large portion of coal used for heating purposes is for household purposes, is it not?—Taking, say, general engineering or machine works, I should think the consumption of coal for heating purposes will not, perhaps, be more than 10 per cent. or 15 per cent. of the total; but if you take engineering works like Armstrong Whitworths, where they have a great many furnaces for armour plate and other metallurgical purposes. I should think they use ten times as much coal for heating as they do for power.

13128. (*Chairman.*) Take a steam dye works, for instance?—Yes, but there, I think, the heating must be in the form of steam.

13129. I agree, but the steam could be produced by gas?—No doubt.

Electric motors have great advantage over gas-engines in their relative higher efficiency when working at less than full load, and occupying much less space requiring less foundation, in being readily susceptible of speed regulation, and requiring much less attention.

In first cost, a user requiring motors of from 20 to 100 horse power will, on the average, spend £3 15s. per horse power in putting down continuous current motors, or £3 11s. per horse power in three-phase motors, whereas if he instals small gas-engines for producer gas the corresponding expenditure will be £7 10s. per horse power.

To summarise, it appears certain that there will be a great development of power stations for the supply of motive power to both large and small users, and a great increase in the motor load of existing electric lighting stations; that these power stations (unless the energy is primarily required for heating purposes) will be electric, on account of the much greater convenience and less first cost to the user of electric motors, as compared with small gas-engines; that the electric generators will be driven by gas-engines worked with producer gas, not so much on account of inherently greater theoretic efficiency of the system, when working under full load test conditions, as on account of the much smaller effect of the fractional load factor and the financial saving owing to the use of lower priced coals and the economy realised from the recovery of the ammonia; and, finally, that an actual saving of fuel by the use of gas plant will be of the order of 65 per cent., as compared with steam plant.

13130. (*Dr. Le Neve Foster.*) That is a saving on fuel alone?—That is a saving on fuel alone.

13131. The saving of money will be greater if you recover ammonia?—Not taken over the total cost of the power, because then you must take into consideration wages, oil, stores, and so on; but the saving in the money cost of the fuel will be greater.

13132. Yes. That is saving in weight of fuel and amount of fuel?—Yes.

13133. As to the saving of cost of fuel, if you reckon in the sulphate of ammonia——?—That will be greater still.

13134. (*Sir George Armytage.*) Would you tell me whether in the comparison of these two plants—the steam plant and the gas plant—the actual machines themselves are lighter? If you were putting up the two model plants which you are here speaking of, is the actual weight of the machinery heavier or lighter in the gas plant than it is in the steam plant?—A steam engine will weigh much less per horse-power than a gas engine.

13135. That is, to produce the same electrical energy a steam engine will weigh much less than a gas engine?—Yes. I am speaking upon the facts as they are at present in regard to that point. It is quite possible that they may change in course of time.

13136. What would be the comparative weight of a 500 h.p. steam engine and gas engine; have you any idea?—It is rather a difficult matter. Steam engines vary much, according to their nature. If you take a high-speed engine, like the Willans' engine, the figures will be very different from those for a slow speed engine.

13137. I mean such an engine as you would use for running dynamos?—Well, you may use either. I think a 500 h.p. gas engine of the particular type I have in my mind (there, again, they are of different types, and vary much) weighs about 70 tons. I am afraid I have not got the corresponding figures for steam engines in my mind.

13138. But you think the steam engine would be lighter?—Yes; I am quite sure it would be lighter.

13139. Of course, that would be an element in the case of foundations, and so forth?—Yes.

13140. Have you taken that into account in comparing your two plants?—I have. Of course, in that respect the gas engine plant will cost more than the steam engine plant.

13141. Yes. You have taken that fact into account in your figures?—I have. You see, that is balanced, on the other hand, by the buildings required for the producer, of which the foundations are very much less than those required for the steam plant, the economisers, and the chimney. The chimney is a very important factor to be taken into consideration.

13142. Comparing the value of electricity with gas, do you not get a great advantage in using electricity, from the fact that you can put small motors all over the place, whatever your work may be?—Yes.

13143. Whereas, using the gas engine direct, you are obliged to have shafting, and so forth, the same as you would with steam plant?—Yes, that is so. That is a very great practical advantage.

13144. And is that not a very important element?—There is no doubt it is a very important element indeed.

13145. But although a very small man in a village might be satisfied to have a 5 or 10 horse-power engine to work the little business he has, he would do very much better by just getting what power he wants from a central system and distributing it to different parts of his building?—Yes, that is so.

13146. Have you made any estimate of the relative proportion of the maximum work which is required in a large town with tramways or railways, or anything of that sort, where the population are all moving at one hour? Of course your plant has to be up to the maximum?—Yes, for tramway work, the average is usually about 30 per cent. of the maximum.

13147. And the minimum might be very much less. I mean, there are times in the day when people are not moving about much?—I am taking absolutely the average over the 24 hours. Of course, the minimum may be nothing at all.

13148. Then, relatively, supposing it is 30 per cent. of the maximum, what are you saving by a gas-driven electric plant at times when the work is not going on so heavily. What I mean is this: supposing that you were up at your maximum, we will say, in the hours of the day when people are returning to their work, and all that sort of thing, and the average is 30 per cent., what would be the average cost when the work was not going on at such a pace? What proportion would you save? Would you save 30 per cent.?—No. You may look at it in another way, perhaps. The gas producer, which is capable of consuming one ton of coal per hour, when standing will not consume more than 40 lbs. of coal per hour.

13149. That is what I want to get at?—You may say, on an average figure, that a boiler when standing under steam will consume about 10 per cent. of what it will when it is steaming at full power.

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13150. So that by using the gas producer you get the difference between 2 per cent. and 10 per cent.?—Yes, the difference between 2 per cent. and 10 per cent.

13151. (*Professor Dixon.*) It is a little outside your proof, but could you tell us at what price a unit of electricity could be commercially produced, taking, say, Lancashire coal at the prices we have been considering, with the recovery of ammonia, and using, say, a Körting gas engine; at what price could it be commercially produced?—Do you mean with a 25 per cent. load factor or working fairly continuously, like chemical works?

13152. Will you give me either of those?—I can give you those for continuous working.

13153. Yes, you have it, I think, but it is not directly given in your proof?—With ammonia recovery, I think the unit can be produced at about ·13d. per kilowatt hour—working with gas engines and recovering ammonia, and not including any charges for interest or rent.

13154. (*Sir George Armytage.*) Is that per unit of electricity?

(*Mr. Briggs.*) That is per Board of Trade unit.

13155. (*Dr. Le Neve Foster.*) With coal at how much per ton?—That is taking coal at 7s., which could be reduced to the equivalent of 2s. 6d. by the recovery of the ammonia.

13156. (*Mr. Young.*) One-sixth of a 1d.?—One-seventh.

13157. (*Mr. Briggs.*) That is the lowest cost fuel work?—Yes.

13158. That is about a tenth of what we have heard of?—I am taking continuous work.

13159. (*Professor Dixon.*) You would put it at about ·13d. using all these economies?—Yes.

13160. And using a gas engine of about 500 horse power, I suppose, you would say?—At least 500. I am assuming a large plant.

13161. Do you mean up to 750?—Well, with units of not less than 500, a plant of at least 4,000 or 5,000 horse power total capacity.

13162. Then would you compare that with the unit of electricity produced by water power, having regard to the initial cost? Of course, in each case I want the initial cost taken into account as well?—It is difficult to compare; the cost of the water power so largely depends on either the rental you pay for the power, or the works necessary to generate it.

13163. You know at what price they are selling it at Niagara?—Yes.

13164. Do you know of any other prices—in Switzerland, for instance?—Of water power?

13165. (*Sir George Armytage.*) What is the Niagara price?—The lowest Niagara price, I believe, is £4 per horse power per annum.

13166. (*Professor Dixon.*) That is for a big quantity, is it not?—Yes, a very large quantity.

13167. (*Dr. Le Neve Foster.*) They are taking it day and night, I suppose?—Yes, day and night—continuously. One can compare that, by working it out, with ·13d.

13168. (*Professor Dixon.*) The point I wish to arrive at is, can electricity be produced in our coal districts at a price which is comparable with that which obtains at Niagara and other places where they have water power?—I should say undoubtedly. I can give you some actual figures bearing upon that point, viz., that with a steam plant, not gas, before the great rise in coal prices three or four years ago, the cost per horse power per year worked out to about £7, and Niagara was charging at the same time £5 or £6.

13169. That was with steam?—Yes, with steam; so that, speaking generally, I think there is no doubt that with gas plant and with coal at present prices power can be produced which will compete in price with water power.

13170. It will be under the Niagara price considerably?—Yes.

13171. Then it will not be true to say that electrical work—I am speaking rather of electro-chemical work—has been kept out of England because we have not got water power?—No.

13172-5. That is not true in your opinion?—It is not.

13176. (*Dr. Le Neve Foster.*) I do not understand this statement: "In July, 1902, there were 78 gas engines of 500 horse power and upwards at work or in course of construction in Europe and America for the purpose of driving dynamos, aggregating nearly 53,000 horse power. At the present time there are gas engines of the 'Körting' double-acting two cycle type alone aggregating 68,000 horse power"?—Yes, the figure of 78 referred to gas engines generally; I do not happen to have the figures accessible for gas engines of all types at the present time, but no doubt there has been a very large increase. I did happen to have the figures of the Körting type which are included in the 78. *Dr. Edward Hopkinson.* 19 Mar. 1903.

13177. But then I do not understand how it is included in the 78, and yet you get to this 68,000 horse power which is more than the total in 1902?—I wanted to show how much we were going ahead at the present moment.

13178. (*Sir George Armytage.*) Even one firm has more than all the rest put together?—Yes.

(*Professor Dixon.*) In eight months?——

13179. (*Dr. Le Neve Foster.*) I understand then that it means in March, 1903, the Körting engines alone mounted up to 68,000 horse power, whereas 8 or 9 months ago the total horse power of all gas engines of 500 horse power and upwards was only 53,000?—Yes.

13180. That was the point I did not understand. Then with regard to the depreciation of steam boilers and producers, which are the worst? In which is the depreciation the most rapid?—I think that would be a very difficult question to answer now. It might be easier to answer in a few years' time. It is only an estimate, but I should say with a Lancashire boiler the depreciation would be very much the same as with a gas producer. But taking the water tube boiler, especially the "Belleville," the depreciation would be very much more.

13181. And in the case of the engines, in which would the depreciation be more rapid—the steam engine or the gas engine?—I think there again there would be no very great difference. A steam engine, having a great many glands, and so on, and small working parts, would perhaps require more maintenance than a gas engine.

13182. Is there not trouble and dust with the gas engine sometimes?—There is. Dust or tar must be removed from the gas before you can use it in the engine successfully—dust from blast furnace gas and tar from producer gas.

13183. (*Mr. Briggs.*) You mentioned gas heating from exhaust of the engines. Is that being done generally now?—No, I should not say generally, but it has been done in several important cases, and done very successfully.

13184. So that is a point to which we must look in future to complete the usefulness of the gas engine?—Yes.

13185. It is sufficiently noticeable to be necessary for a large plant?—Yes, quite. You see about 40 per cent. of the heat supplied to the gas engine goes away in the exhaust, and you have to supply to the producer about two and a-half tons of steam for every ton of coal burnt in the producer. I know of several instances where they are actually supplying half that weight of steam from the exhaust gases; but there is no reason why the whole should not be obtained.

13186. Then it requires some little auxiliary plant to make a start, as it were, to get the thing going before the gas is produced—to blow up?—Yes, of course that would be necessary.

13187. In reckoning your steam cost have you considered the steam turbine?—No, I have taken the figures of ordinary steam engines. Steam turbine figures, so far as present experience goes, would be a little better, but not very much.

13188. They would be a little lower in cost?—A little lower in fuel cost.

13189. And, I suppose, on a large unit they are claimed to be a little better in economy, are they not?—Yes, a little better, but not very much. But then I do not know how that would be if you take into account the load factor of 25 per cent., because the turbine efficiency is not so good at low loads.

13190. The startling point of your evidence was, of

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Dr. Edward Hopkinson.

19 Mar. 1903.

course, the enormous saving on the poor load factor—the 25 per cent. load factor?—Yes.

13191. Is that saving really almost entirely obtained on the difference between the 2 per cent. and 10 per cent. consumption, when the producers or boilers respectively are banked?—No, it is not. You may take it that the relative economy of the gas engine when working at a fractional load is very much the same as a good steam engine, but there are not the losses going on in radiation from the pipes and condensation, and so on.

13192. That is a very great item in the steam engine?—Yes. And then with producer plant if you stop a unit you stop all the auxiliary portion—will stop the blast for the producer, and you stop the water circulation round the gas engine. With a steam pump you still have to be pumping a certain amount of steam into the boiler—your feed pump has to be going, and all auxiliary plant.

13193. You do not touch upon the question of water, but I suppose the use of water would be a good deal less with the gas plant than with the boilers, would it not—for cooling and other purposes it would be less than with the boilers?—Yes, it would.

13194. So that where water was an object that would be an additional economy?—Yes.

13195. Must the water required for the cooling be as good as the boiler water, we will say?—For the cooling of the engine?

13196. Yes.—Yes, it must be good, but it can be used over and over again.

13197. It is not boiled away, in fact?—No.

13198. It is raised in temperature and reduced again by cooling?—Yes, it is only raised some 30° Fahr.

13199. Then the probability is that there would be a great deal less actual consumption of water?—Yes. I have not worked out the actual figures, but I think it would be very much less.

13200. Perhaps you would look into that for us, would you? Will you make a note of that? It would be very interesting to know?—Yes, I will.*

13201. Because there are many places in which water is very, very important?—Yes.

13202. You would require, I suppose, a non-caking coal entirely for the gas producer, provided you did not use anthracite—I mean you could not use a highly bituminous coal?—No, I think not, successfully.

13203. That might limit you slightly?—Yes.

13204. I suppose you have had no difficulty in getting sufficient suitable non-caking coal?—No, I think there would be no difficulty.

13205. On the other hand, you use coal with a much larger ash percentage than you would under a boiler successfully?—Yes.

13206. Is 4s. 6d. per ton for sulphate recovery a net recovery after the cost of treating and acid, and so forth?—I think it is taking actually the value of the sulphate of ammonia against the cost.

(*Sir George Armytage.*) Selling price.

13207. (*Mr. Briggs.*) Then you would have to add to the fuel cost, the acid cost, the labour cost, and the depreciation of such extra plant?—Yes, these items have to be taken into account.

13208. It would not be all profit?—No.

13209. That item looks a very enormous sum to get back for your coal?—Yes, the additional costs are very small.

13210. Do you know the Electrolytic Alkali Company's Works?—No, I do not.

13211. They are using electric power, I believe, absolutely constantly, in the new process, are they not?—I have no doubt they are.

13212. But you do not know whether it is gas they are using or not?—No, I think not; I think it is steam.

13213. (*Mr. Sopwith.*) With regard to the maximum radius you have mentioned, is that the established economical distance from the central station for the distribution of gas?—I think it is established that that radius is quite possible and economical, but probably you could transmit to a much greater distance.

13214. You would probably?—Yes.

13215. But that is as far as it has gone at present?—Yes, about that.

13216. With respect to the producers, you have dealt with them on a large scale. Can you give us an idea as to the smallest producer which would be economical for a small tradesman—say a small manufacturer—to put up?—As compared with steam plant.

13217. Yes.—I think there is no doubt an economy in however small a size. There are not so many of these small producers in this country, but in Germany there are quite a large number of very small size.

13218. (*Professor Lapworth.*) I should like to ask you a question as to this ·13d., at which you think the Board of Trade unit could be commercially produced in Britain. Is that estimate purely theoretical, or founded upon facts that you know already? Are there any gas engines made of such a size that the cost does actually work out at so low a figure, or is that under the very best conditions possible—largely theoretical?—No, that particular figure is arrived at from a station where all the costs of steam plant were perfectly well known, and the costs of the gas were deduced from that.

13219. Your conclusion, then, is founded upon facts so far?—Well, I could not say that I know of any figure of a gas-driven station where that rate of ·13d. per unit had actually been realised.

13220. No, but it is within, may I say, practical politics?—Yes, undoubtedly.

13221. Then, that being the case, if the cost at Niagara is from £4 to £5 per horse-power per annum (that is, from ·13d. to ·17d. per horse-power per hour, or ·17d. to ·21d. per kilowatt), we shall soon be able in Great Britain to underbid Niagara so far as price is concerned?—Yes.

13222. (*Mr. Brace.*) I note that you say, "In the near future a considerable proportion of the power required by small users in towns will be derived from central stations for the supply of electrical energy, and elsewhere from the larger power stations which are projected in various parts of the country." The point I wish to put to you is this, that the real meaning of that resolves itself into this, that a central station could supply electrical energy much cheaper than a small consumer could manufacture for himself?—Yes.

13223. If a number of municipalities could agree to amalgamate for the purpose of putting down a central power station, there is no reason why those municipalities should not be able to manufacture as cheaply as a private central company such as this, is there?—No, I think not.

13224. Again, you say, "On a full load test run the coal consumption, expressed in terms of Welsh coal," and so on. What does that mean?—I took Welsh coal as having the highest heating value.

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* Note subsequently sent in by Dr. Hopkinson in answer to Question 13200:—

It is difficult to make a general comparison of the water required for steam and gas plants respectively, as much depends upon the local conditions; but, assuming in the first case that the steam plant is condensing, and the circulating condensing water is cooled and used again, then the only water required is the feed "make up" and the circulating water "make up." If careful precautions are taken to prevent waste, the feed "make up" may be taken as not exceeding 5 per cent. of the water evaporated. The circulating water "make up" may be taken as 5 per cent. of the water required for condensing, which, under ordinary circumstances, is 35 times the water evaporated. Under these conditions a 25,000 i.h.p. steam plant requires 64,000 gallons of water per hour.

A gas plant of similar size, with ammonia recovery, requires a weight of steam equal to 2½ times the amount of coal consumed in the producer, of which 1½ times the amount must be supplied from external sources. There is also the "make up" water required for the cooling and scrubbing, which may be taken as 5 per cent. of the water used, and finally there is the "make up" for the circulating cooling water through the jackets of the engine, which may again be taken as 5 per cent. of water required. Under these conditions a 25,000 h.p. gas plant requires 16,100 gallons of water per hour, as against 64,000 gallons per hour in the case of a steam plant of equal capacity.

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13225. That would be Welsh steam coal?—Yes, Welsh steam coal. It is taken as a standard of the value of coal.

13226. Is it Welsh steam large, or mixed, or small?—I should say 15,000 British thermal units would be a very high class of large coal.

13227. Then you would place Welsh coal for this purpose as the highest class of coal you would get?—Yes.

13228. Now which would be cheapest, taking a distance of 20 to 40 miles, to transmit electrical energy over that distance or gas?—I am afraid I cannot answer that question. It is rather a difficult one; and then, again, the answer would depend so much on local conditions. You would have to take all charges into account—interest on capital outlay, and so on. It would turn upon the question first whether you could take your electrical current by overhead wires or underground wires. The initial cost is enormously different. Then with a large gas main the wayleaves might be a very serious matter.

13229. It all depends upon all the circumstances, then?—Yes, entirely. I think a general answer to that question is practically impossible.

13230. Could you not take a kind of state of comparative circumstances in order to make a calculation like that?

13231. (*Sir George Armytage.*) Could you put it in this way—that they would both have to go underground, and the wayleave would be similar?—Yes. I have not made the calculation as to the actual costs in the two cases, and, of course, there is not much actual experience about the transmission of producer gas in that way.

13232. (*Mr. Brace.*) If you find you are able to do that perhaps you will send us that also?—I will make a note of it and see if I can.

13233. (*Sir George Armytage.*) Can you give us your idea as to the comparative life of gas engines and steam engines or, in other words, as to the relative depreciation?—I think the cost of maintenance (that is, of sundry repairs) would be very much the same in the two cases. On the other hand, I should think there is more probability of improvements in gas engines than there is of improvements in steam engines.

13234. That I understand.—So that a gas plant may be out of date sooner than a steam plant. *Dr. Edward Hopkinson.* 19 Mar. 1903.

13235. What you mean to say is that a man may pull out a gas plant sooner than a steam engine, and therefore a steam engine has a longer life to prove its experience? That may be, but supposing you take a 100 horse-power gas engine provided to-day and a 100 horse-power steam engine, and put them both in use, which would last the longest with an equal amount of work on them?—I do not think there is any reason for any substantial difference between them.

13236. But as regards boilers as against producers, what is your opinion?—Well, I stated that I thought, taking a Lancashire boiler against a producer, the depreciation would be practically the same; but taking a more complicated form of boiler—a water-tube boiler—the boiler would depreciate more rapidly than the producer.

13237. Then we may take it generally, that as regards capital cost you think gas plant and steam plant are about the same, and as regards wear and tear they are about the same?—Yes.

13238. And we have not got to take that into account much in forming our opinion about economies?—No, I do not think you have.

13239. (*Professor Dixon.*) A gas plant will occupy more room, I suppose? You must have a holder for it, must you not?—No, the large producer plants are not worked with a holder at all.

13240. Would you not work it with a holder?—No, the storage is too costly, and it is unnecessary, for the very reason I have been trying to point out—because you can shut down with such facility.

13241. (*Sir George Armytage.*) You get rid of the boilers, and you get rid of the chimney, and you get rid of all the area that those take up?—Yes; but as against that, you have to put in the producers.

13242. Yes, but do you take it that in round figures a similar capacity gas plant occupies about the same space as steam plant?—Yes. I did go into that particular point in one case, and I found the space was practically the same.

Dr. Harold A. Des Voeux, called; and Examined.

13243. (*Sir George Armytage.*) You have been good enough to come here to give us some evidence on behalf of the Coal Smoke Abatement Society?—Yes.

13244. Would you be kind enough to tell us generally what the work of your Society is?—Our work was divided into two compartments, I think I may say, first of all: one was to try and get the local authorities to enforce the law with regard to the abatement of smoke from factories, no matter how such smoke was produced. As you know, before we came into existence in London—our work principally lay in London, and does at the present time—the law was practically neglected; there was no enforcement of the law, or hardly any, and our principal object was to bring before the local authorities sufficient evidence to convince them that the law was in abeyance, and that it ought to be carried out. That we have done ever since we have been in existence. We have always one or two Inspectors going about London observing the chimneys, and observing the amount of smoke from the chimneys. That evidence is brought before us at fortnightly meetings, and if we think that the cases are strong enough we report them to the local authority.

13245. Those Inspectors are paid by your Society?—Yes, they are paid entirely by our Society out of subscriptions voluntarily made.

13246. Are they paid quite apart from the Inspectors whose duty it is to enforce the law against the nuisance?—Yes, entirely. Even at the present time in some districts of London they have no smoke Inspectors at all. In other districts, since we have been in existence, inspectors have been engaged to observe the smoke; in others again at the present time there are no Inspectors at all.

13247. Have you called the attention of those districts to the matter?—We have. In some districts we act practically as smoke Inspectors.

13248. Do they pay you?—We have had a guinea from them occasionally; but we do not try and make money in that way. We are very glad to take it if people say: "We think you deserve money"; but we do not think it is a good plan to say to the local authorities: "You have not got Inspectors, we will do the work, and you will pay us." We think if we did that the local authorities would think we were trying to make money out of them. *Dr. Harold A. Des Voeux.* 19 Mar. 1903.

13249. But you would say to the local authorities: "We think you are not doing your duty, and we shall follow the matter up, and report you to the Local Government Board"?—Yes, we have done that; but the Local Government Board do not take any notice. That is one of the questions coming up before the Committee to-morrow—that we have been unable to get the Local Government Board to act.

13250. Is there any particular work of your Society besides that?—There is the work we have commenced with regard to trying whether anything can be done in respect of the domestic grate, which is entirely outside the law. I mean to say, anyone in any private house can emit as much smoke as he likes; there is no law which governs the matter in any way whatever; and we are trying to get the London County Council to take action in the matter, and I hope they will—they are considering the matter now. We have done a little ourselves also, but it is a very difficult and big question, and one which requires an enormous amount of work which our people certainly cannot do. It requires money and time.

13251. Is it your view, or the view of your colleagues, that by the emission of this smoke, fuel is wasted?—Certainly. We have never yet, in all the factories we have reported upon (I think you have our report before you—Report of the Coal Smoke Abatement Society, 1902, and you will see what a large number they are) had one complaint that we have put any one factory to any expense beyond the initial

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Dr. Harold A. Des Voeux

19 Mar. 1903.

expense of putting in proper appliances or mechanical stokers, or whatever they put in. It is not our business to know what they put in. We forbid our Inspectors to go into any premises, except with the representatives of the local authorities.

13252. As a private Society, you cannot enter upon another person's premises to see what they are doing?—We cannot, we have no power; therefore, we forbid our Inspector going on to any premises except in association with the representatives of the London County Council or of the Boroughs in London. We have absolutely forbidden them to go, except under those conditions.

13253. What has been the result of your action?—The result has been enormous, if you look at all the chimneys which I used to look at years ago, and which one saw emitting smoke; I do not know any that emit smoke now. When any borough in London makes up its mind that the smoke must be stopped, they stop it; but when the borough says: "You are emitting smoke, you are very naughty boys, and we wish you would not do it," they go on emitting smoke. When the borough says: "You shall not go on emitting smoke; we have made up our minds about it," then the smoke is stopped.

13254. Have you or your colleagues made any sort of estimate of the percentage of waste caused by the emission of smoke?—No; I am sorry to say we have no experts capable of doing that. We are a purely voluntary Society, and we have not any experts belonging to it.

13255. In what way do you think you can assist us in our inquiry, which is for the purpose of ascertaining how the fuel of the country can be economised?—The only way we can do it is by these small tests that are made by the sub-committee of the Society for preventing the emission of smoke.

13256. Surely the waste of coal in the smoke which is emitted in London is nothing as compared with the amount of waste going on all over England in factory districts?—I admit that.

13257. Are you purely a London Society?—No, but we are almost limited to London in our efforts by reason of the want of means—not from want of will, because most of the subscriptions are obtained in London. We have many applications to deal with smoke in provincial towns; for instance, we have many applications from Leeds, and Leeds is one of the towns which, as soon as we feel at liberty, we are going to try and tackle. There is plenty to do in Leeds, and there are a great many complaints from that city, but we have not felt ourselves at liberty to relieve Leeds at the present time, because there is such an enormous amount of work to do in London.

13258. I see you have a very large council?—Yes, we have a large Council.

13259. What are you proposing to do as regards the domestic grate?—We are trying to find out whether a grate which emits a small amount of smoke is one that burns a small amount of coal, and we have carried out tests which were made primarily with the object of seeing whether there was a great difference in the emission of smoke from different grates. We also discovered, incidentally, that those which emitted the least smoke were the most efficient heat-givers and burnt the least amount of coal. I have just finished, yesterday, another series of tests on domestic grates, for which we are offering a prize of £50, and I may say, roughly, that I think the same fact will be proved there, namely, that the grate which gives the greatest amount of heat also burns the least amount of coal, and emits the least amount of smoke. Efficiency in those respects is combined with economy.

13260. Have you got those tests with you?—Do you mean the new ones?

13261. Yes.—No, because they were only finished last night, and the figures take an enormous amount of working out.

13262. I daresay you would not mind sending them to us afterwards?—Certainly, I will let you have them, afterwards.* The difference there is just as great as in the other case. I have here a copy of the results of the original tests, and I can give you any facts and figures from them which you require, but I should think the result would be exactly the same in the new tests.

13263. I understand that Sir William Richmond estimates that in London the waste of unconsumed carbon is about 6,000 tons per day?—Yes. I do not know how he gets that figure.

13264. You are not prepared to substantiate that?—No, I am not.

13265. Then, as to the remedies which have been suggested. The first is the use of anthracite coal. That is very expensive, is it not?—Yes, to buy, but it is not expensive to burn; it is a hot coal. The price in the last few years has been exorbitant, because there has been a great run upon anthracite coal, but I do not think, judging from the small use I made of it for a year or two in my house, that it is very much more expensive.

13266. It goes much further?—It goes much further, and the waste from it is very little.

13267. What do you say as to the use of gas for household purposes?—Personally, I cook entirely by gas now, and I do not think the expense is greater than cooking by coal—that is, if you have a cook who will try and save your money.

13268. Some cooks will always leave the gas burning?—Yes; but if you impress upon your cook, as I always do, the advantages of gas to her, you find that they all like to use it. I have cooked entirely by it for five years now, and I find it in every way satisfactory.

13269. You do not think it costs more than it did to cook by coal?—No, I do not think it costs more. I do not heat my water by gas. I find that people who cook by gas also have a coal cooker as well, and then they find they are burning both, and they still have their old bill for coal and their gas bill as well. Now I have got over the difficulty by heating my water in a coke-boiler; I burn all my rubbish in it as well; of course, it is not completely smokeless, but that is by the way. I heat all my water by coke, and I spend about 1s. 6d. or 2s. per week, and throughout my house I get hot water, and at all times nearly, from half-past seven to twelve o'clock at night, I get a temperature of 150° to 170°.

13270. At the top of the house?—All through the house.

13271. (*Dr. Le Neve Foster.*) That is hot water for baths, and not heating the house?—Well, I have three radiators from it also. I found I had so much hot water that I put on three radiators, which I find of great use in the passages. That is done very economically with just a simple coke boiler. Then the gas is kept simply and purely for cooking, and I do not think, if it is properly used, it is an extravagant way of cooking.

13272. (*Mr. Briggs.*) Have you a kitchen fire in winter as well?—No, I have a coke boiler in the kitchen, and the kitchen is quite warm.

13273. (*Sir George Armytage.*) That is sufficient to keep the kitchen warm?—Yes, it is quite sufficient, and I have never had a single complaint, and all the cooks like it.

13274. The use of oil has also been advocated?—Well, there are oil cookers, but I do not think they are much use; I see them in some houses. We have mentioned them in the papers of the Society, because there are people who write and say, "You have not mentioned oil."

13275. You would not regard oil as practical for household purposes?—I have not tried it myself, so that I cannot speak to it, but I know people who use oil, and who like it.

13276. The second set of remedies suggested is with regard to the use of a proper grate?—What we think is that householders should be made to use a grate which is the best possible; that is to say, at the present time it is left to anyone to say, "I like that grate; it is a very nice-looking grate, and I will have that in my house." Some of those very nice-looking grates are extremely smoky, and they emit an enormous amount of smoke, and we think there should be some authority to say, "This grate is a very smoky grate, and you shall not be allowed to use it."

13277. Do you think the British public will stand that?—I think the British public will, if the advantage of it is pointed out to them. They submit to every other sanitary law, and the only one they are not all subject to is that relating to smoke.

13278. They might be told that they were not to make smoke, but I do not think they would like to be told

* See note on page 189.

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what sort of grate they should put in?—I think, if they got a very bright fire from another grate which is not less efficient they would not mind. I do not think it could all be done straight away, but I think there should be some public authority to guide people as to what is the best, and I think, when people saw what was best, they would be very glad to take it. I do not think there would be any difficulty in the long run, but I quite agree you cannot at the present time say to everyone, "You must take out the grate you have, and put another one in."

13279. You think the Government could assist this?—I think the Government could exist by example. They can and do try in the Government offices the grates which are recommended to them for smokelessness.

13280. Shall we have a report upon those?—I do not think they have gone far enough at present; they have not enough in the offices at present, but they are putting them into new offices which they are building.

13281. You probably would be watching that matter?—One of the Government architects is watching these tests; he comes to see them practically every day. They are watching the tests in the grates, and they have asked me to test two or three grates for them.

13282. Then we may have an opportunity at some future time of getting some records upon the matter?—Yes, the figures are being worked out now; the actual tests were finished yesterday, but the results will take some time to work out, because there is an enormous number of figures of temperatures, and so on.

13283. The next matter which is mentioned is the central heating of buildings?—That would make an enormous difference, but there is a tremendous prejudice against it, especially in the mind of the Government clerk, I find. A Government clerk finds he is terribly injured if he has not a fire in a grate to poke.

13284. You find the failing in Government offices is that they like a fire in their own rooms?—I have no doubt about it, but I believe they would like a warm, draughtless room as well.

13285. Sir William Richmond has some views on the point, I understand?—Yes. Sir William Richmond has an opinion which is rather different from mine, namely, that the greater part of the smoke of London is produced from factories. I suppose it is impossible to say whether the greater part is, but there is an enormous amount produced from domestic fires as well, and you will not get in London a proper amount of sunlight unless you get rid of a large amount of the smoke which is produced from grates. The ordinary kitchener emits an enormous amount of smoke, I think.

13286. I take it that your object is generally to show that there is a certain amount of waste of fuel?—Yes.

13287. And that a good deal of it might be saved if there was some law which required domestic fireplaces to consume smoke, the same as there is with regard to factories?—Yes. Of course, I do not think that public opinion at the present time would allow of any law of that kind to be passed, but I think public opinion is quite prepared to be educated on the subject. I do not think anyone minds having a good grate as long as they know it is a good grate. For instance, I think the man who made the grate that came out best in our original tests has done a very good business as a result of these tests. I think he has sold a great many more of the grates since the tests than he did before. Certainly the better the grate the better the fire. I maintain that you can save from 20 per cent. to 25 per cent. of your coal by having a proper grate.

13288. And that you will get the same heat?—You will get greater heat, or the same heat with a smaller consumption of coal, if you like to put it so.

13289. How can you account for it that people whose business professionally it is to produce these grates do not produce something of that sort?—Because they all claim that their grates burn, say, 50 per cent. of the coal that is burnt by other grates—they all do that, and nobody knows which is really the best. Every grate maker says, "If you use my grate you will not burn half as much coal, and you will get twice as much heat," but there is no independent authority to say which is the best grate.

13290. What test do you use for the purpose of seeing whether these grates give the same amount of heat with a less consumption of coal?—We have made the tests this time and last time rather differently. In the former grate we burnt the fire to its greatest capacity—that is to say, we tried, keeping the fire up to a certain level, what heat we could get out of it, and we tested that for eight hours for three days.

Dr. Harold A. Des Voeux.
19 Mar. 1903.

13291. How do you test that heat—by a thermometer at different distances?—Yes, by a thermometer at different distances from the fires, thermometers in the hall outside, and then thermometers in each room. This time we have done rather differently. We have asked the fire to do a certain amount. We have assumed that in cold weather, when people are using fires, when they go into a cold room they want the temperature of that room raised by a certain amount, which we have arbitrarily fixed at 20°, and we have asked the fire to do that and to raise that temperature 20°.

13292. You weigh all your coal?—Yes.

13293. And you have made a record of the various grates that you put in?—We have a description of the grates, and we weigh all the coal that is put in, and we weigh the wood. We keep the fire burning three days for eight hours a day. Then it is put out, and we afterwards weigh the partially-burnt coal that is in the grate and the ashes. Then we have a man in the house opposite watching the smoke from the chimney the whole time, and we keep a chart of the smoke.

13294. Do you act upon his judgment as to whether it is dense or partly dense?—He has a standard.

13295. A photometer?—For colour.

13296. Then I suppose he says it is 1, 2, 3, or 4?—Yes, and he keeps that marked on a chart which he has before him.

13297. What about the construction of your chimneys?—We take an ordinary chimney.

13298. Do you test all the grates in the same chimney?—All the grates one after another in the same chimney. Of course, there is the difference in the weather—that you cannot get over. But we thought it better to test them all in the same chimney in different weathers.

13299. You make a record, of course, of the weather?—We keep the meteorological records, and we know exactly the weather; but we find, no matter what the weather is, a grate that burns in a certain way on one day will burn the next day exactly the same, and that the weather makes extraordinarily little difference to a grate.

13300. (*Dr. Le Neve Foster.*) I gather your difficulty is to get the local authorities to enforce the law?—In most parts of England the local authorities will not enforce the law.

13301. Do you mean they refuse to do it?—Certainly. At Brentford we have actually had a quarrel with them, and they absolutely refused to enforce the law. We appealed to the Local Government Board, and the Local Government Board wrote to them, but there was no result at all from it. They absolutely refused to carry out the law with regard to smoking factories. That is the only place we have had an actual quarrel.

13302. What is the Brentford authority? Is it a district council?—It is a local board.

13303. Do you mean to say that they are defying the Local Government Board?—Yes, I think so.

13304. Or do you mean that the Local Government Board are lukewarm, and do not care about it?—The Local Government Board do not want the work really. I am perfectly certain of that. We are going to try and send a deputation to them now, but I fear that it will be fruitless, because we have given them lots of opportunities of carrying out their duties. With regard to Brentford, they absolutely refused to act, and the only way of tackling Brentford was to go to another Department. We thought of going to Kew Gardens, and we got into communication with Sir William Thistleton Dyer, and we found he had been making complaints about the smoke there, and so we observed it, and we got a three months' record of the smoke from Brentford, and then we appealed to the Office of Works, the Department responsible for Kew Gardens, and they said, "Yes, this is a very bad story, and if your story is true we will prosecute." So we got some further evidence, and as a result of our further evidence the Office of Works, in protection of Kew Gardens, said they would prosecute the owners of the offending chimneys. A writ was

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Dr. Harold A. Des Voeux.

19 Mar. 1903.

issued by the Treasury Solicitor against the worst of the chimneys. The ultimate result was that the nuisance was stopped.

13305. What remedy would you propose in order to wake up the Local Government Board?—The matter is coming before our committee to-morrow, and I am going to propose to the committee that we ask the Board to receive a deputation. Then if they refuse to receive a deputation, which I think they may do, we shall make it public in Parliament, and we shall get some of our Members of Parliament who are interested to take the matter up, or we shall bring it before the public in the papers, because the way in which they neglect their duty is really scandalous. They will not force the local authority to do it—there is no question about that at all. We have case after case of chimneys smoking for 40 or 50 minutes continuously, and they will not take any action at all.

13306. That is in the case of factories. Then there is the other point with regard to these domestic fires. Are you not of opinion that the quantity of coal consumed in domestic fires in London is very much greater than the quantity consumed in factories?—I cannot find any figures. There are no figures, and even the coal merchants differ about that.

13307. (*Mr. Brace.*) It is enormously greater in domestic chimneys?—You will find that authorities will differ, because I am always asking the coal people, and I cannot get any figures. I wish we could.

13308. Excluding gas?—Yes, excluding gas.

(*Mr. Briggs.*) I will tell you where I think you might get the figures—by going back a few years to the time when the Coal Tax was still on, and they would still be applicable if you got them from the time when it was put on. The railways published a list, if you remember, of all the collieries from which the coal came, and I think by getting hold of any man who takes an interest in the trade, and knows the collieries, you would be able to discover almost exactly what the class of coal was.

13309. (*Sir George Armytage.*) It would be quite possible to get a very fair estimate?—Yes, it would be quite possible, and we should be very glad to do so. I think the amount of coal consumed in London is about 14,000,000 tons annually.

13310. (*Dr. Le Neve Forster.*) But have you not, as a matter of fact, a very large amount of smoke in districts of London where there are no factories whatever?—Yes, we have; but, then, the smoke blows according to the prevailing winds.

13311. But there are days when there is very little wind, and you see the smoke hovering over the houses?—Personally, I am a great believer in the amount of smoke that comes from domestic chimneys, and especially from kitchen fires, and I do not think the Legislature ought to be afraid to deal with the kitchen fire question; for instance, in making bread, a baker is not allowed to emit smoke. We hope to prove that a club is not allowed to emit smoke, but that is a question which is at present *sub judice*—whether a club is a private house or not.

13312. Is there a better grate than the "Florence?"—I do not know, because a good many of the manufacturers are afraid of having their grates tested. There is no force upon them to do so, but I think there ought to be.

13313. With regard to the coal you are burning in the grate, are you always using the same coal?—We insist upon always using the same coal. As a matter of fact, these tests are done with the assistance of the Office of Works, and they supply us with the same material as used in the Government offices.

13314. It is, in fact, a caking coal?—Oh, it is a dirty coal; it is a smoky coal.

13315. Have you made any tests with regard to using coal in lumps of a uniform size in the grate?—No; I have taken the coals just as they came. I thought that was one of the things we were bound in fairness to do. A great many people in London buy the cheapest coal they can get, which the coal merchants send them an advertisement of; and if they see a coal quoted 17s. they will buy it.

13316. May it not be important to educate people as to the best way of burning coal in a domestic grate? May it not be a bad thing to have huge lumps of coal twice as big as one's head to put on? May it not be better to have small lumps of uniform size, say the size of an egg? May that not be better for the heat and for the purpose of avoiding smoke?—I daresay it would; but, then, I do not think at the present time it would be worth taking up any tests of that kind, because I do not think we could force anyone to use particular sizes of coal. For instance, the Government will not do it. The Government put out their tenders for coal, and they take an estimate, which I conclude is the lowest, and they buy an enormous amount of coal every year for their offices.

13317. But, of course, there are two important points, namely, to show how the coal sold at the present time is to be utilised and to point out how coal might be better utilised if it were prepared for the purpose?—No doubt that is so; but, you see, we are only a voluntary Society, and very few of us have got much time to spare. I, personally, am a very busy man otherwise, and I have not much time. There is an enormous number of tests which ought to be carried out.

13318. Would it not be a good plan for us to have one of those grates put in to see how it works?—But then you could not judge the amount of smoke.

13319. No, but we might judge as to the amount of heat. Of course, we could judge to a certain extent as to the smoke?—We shall be having a grate put in next week; Florence has invented a new kind of grate, which he says is an improved one, and I am going to test that next week.

13320. You do not propose at all to abolish open fires?—I do not see that that is possible at the present time; it does not matter in the least what is economical, because I know perfectly well the British public will not allow open fires to be abolished. Still, I think the number of them might be diminished; for instance, I think that numbers of people sit in a dining-room at the outside for two hours in the day, and they keep the dirty coal fire burning there all day long; whereas, if that room were properly heated by some other means it would make a great difference to the smoke of London. Then, I think the kitchener would, of course, make an enormous difference, because every one of the 600,000 houses of London has a kitchener.

13321. I know the kitchener by experience, and it is frightfully wasteful?—If you go along Piccadilly, as I do, in the morning, you will see some of those big houses emitting smoke, upon my word the Duke of Wellington's house is like a factory chimney in the morning; in fact, some of the factories do not emit so much smoke as the Duke of Wellington's house. Now, I have often compared that with the Wellington Club, which is just opposite; the Wellington Club comes under the Act, and the Duke of Wellington's house does not.

13322. (*Sir George Armytage.*) Why does it come under the Act? Do clubs come under the Act?—Well, they all admitted it until the Sports Club contested it the other day, and the magistrate (Mr. Kennedy) held it was a private house, and, therefore, did not come under the Act. But all the other clubs which have been prosecuted by the City of Westminster have come in and stopped their smoke. Now, of course, it will all begin again until we appeal in this case, which we are going to do; we have to settle whether the club is a private house or not.

13323. (*Mr. Briggs.*) In the different grates you have tried, I suppose you generally find that they are well surrounded by fire brick?—Well, curiously enough, one of the grates which came out second best in the competition was made entirely of iron; I do not think it had a fire brick at all in it.

13324. There is a plan which has been recommended of closing up the end part of the grate entirely, so as to prevent the draught through, and keep a sort of chamber of warmed air?—Yes.

13325. I suppose that is much better, is it not?——

13326. (*Sir George Armytage.*) That is the Teale grate?—The Teale grate did not come out as well as the Florence grate, which is completely open. I do not know whether you have seen these figures which I have here?

13327. (*Mr. Briggs.*) No, I have not seen them, but I should be very much interested in seeing them?—I will put in these Tables. From them you will see that we have the greatest rise of temperature with the least amount of smoke. I believe we shall get exactly the same results from the tests we have just completed.

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TABLE I.—*Summary of Tests on Six Domestic Open Fire Grates, with the Quantity of Coal Burnt, the Temperature of the Room, and the Smoke Observations made, during the Summer of* 1901, *all used (one after the other) for Heating the same Room and Burning the same Smoky Coal. Mean Results of Three Days' Tests on each Grate for Eight Hours each Day.*

Dr. Harold A. DesVoeux.

19 Mar. 1903.

(1) Name and Number of grate.	(2) Amount of dry coal burnt (plus half the weight of wood for lighting) in eight hours in pounds.	(3) Amount of unburnt residue left in the grate at the end of the day in pounds.	(4) Number of stokings per day of eight hours.	(5) Mean temperatures of the air in degrees Fahrenheit. In the hall.	(6) At the end of the room.	(7) In front of the fire.	(8) The mean of columns 6 and 7 less column 5; or rise of temperature.	(9) Degree of smoke by smoke scale or average intensity by observation. Mean three days.
Florence—No. 4	19·00 Coal. + 0·75 Wood. = 19·75 Total.	2·0 = 10·1%	4·0	67·8	77·1	92·6	17·0	
					Mean 84·8			
"Tropic" Helyear—No. 3	22·60 Coal. + 0·75 Wood. = 23·35 Total.	1·7 = 7·2%	4·0	74·8	78·4	91·6	10·2	$\frac{6}{16}$
					Mean 85·0			
Teale—No. 2	26·30 Coal. + 0·75 Wood. = 27·05 Total.	4·0 = 14·8%	5·7	72·2	76·2	92·0	11·9	$\frac{6}{16}$
					Mean 84·1			
No. 1 old; name unknown; no blower	30·10 Coal. + 0·75 Wood. = 30·85 Total.	5·0 = 16·2%	9·3	66·1	Not taken.		—	$\frac{8}{16}$
Well Fire—No. 5	28·0 Coal. + 1·0 Wood. = 29·0 Total.	3·3 = 11·4%	5·0	71·0	76·0	91·6	12·8	$1\frac{1}{16}$
					Mean 83·8			
No. 1 A (old), with blower; same grate as No. 1.	35·50 Coal. + 0·75 Wood. = 36·25 Total.	4·0 = 11·0%	10·6	70·3	75·6	94·7	14·3	$1\frac{1}{16}$
					Mean 85·1			
Smith and Wellstood—No 6	27·60 Coal. + 0·75 Wood. = 28·35 Total.	2·7 = 9·5%	5·6	72·3	76·9	92·3	12·3	$1\frac{1}{16}$
					Mean 84·6			

The temperatures of the rooms, &c., were taken every half hour. These tests are placed approximatively in order of merit. The experiments were carried out by Dr. H. A. Des Vœux and the late Mr. Bryan Donkin, M.I.C.E., M.I.M.E., &c., with two assistants (Messrs. R. Hawkins and J. W. Smith).

Smoke scale 0 to 5. 0, no smoke; 1, light gray; 2, darker gray; 3, very dark gray; 4, black; 5, very black.

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Dr. Harold A. Des Voeux.

19 Mar. 1903.

TABLE II.—*Tests on Six Domestic Open Grates in London. Details of Smoke Observations. See Smoke Scales 0 to 5. Observations every Five Minutes during Eight Hours = 96 per Day. 23 Days' Tests, Seven to Eight Hours, Burning the same Coal and Heating the same Room. Maximum Smoke at Lighting Up and after each Stoking. Warm Summer Weather, June, July, and August, 1901.*

Number of grate.	Name of maker, &c.	Date of test and number of hours.		Number of smoke chart.	Smoke results, Nos. 0 to 5 smoke scale.					Mean for the three days of each grate (Column 6).
		Date.	Hours.		Mean for the whole day.	Lighting up only.	Maximum during the whole day.	Minimum during the day.	Other notes on smoke.	
		1901.								
No. 1 (without blower.)	Existing grate in room, name unknown.	June 27th.	7	1	1 (barely).	2 for 15 minutes.	2	½ for 30 to 40 minutes.	Never 0.	
	,,	,, 28th.	8	2	$\frac{6}{10}$	1½ for about half an hour.	2 for 2 minutes.	for some hours.	,,	$\frac{6}{10}$
	,,	July 1st.	8	3	$\frac{6}{10}$ (barely)	2 to 2½ for one hour.	2½ for a few minutes.	0 to ½.	Zero at end of the day only.	
No. 1A (with blower).	,,	,, 3rd.	8	4	1 (fully) (1·1).	1½ to 2½ for one hour.	2½ six times for a few minutes each.	½ for one and a half hours.	Never zero.	
	,,	,, 4th.	8	5	1½	1½ to 3 for one hour.	2 and 3 seven times for a few minutes each.	½ for one and a half hours.	,,	1½
	,,	,, 5th.	8	6	1 (fully) (1·1).	2 to 3 for half an hour.	3; 1½ nine times for some minutes.	½ (about) for one hour.	,,	
No. 2.	Teale "Front Hob."	,, 10th.	8	7	¾	1½ to 2½ for half an hour.	2½; two to four times for a few minutes.	0 to ½ for three hours (about).	Zero or no smoke for one hour.	
	,,	,, 11th.	8	8	½	1 to 2 for half an hour.	2; 1 to 1½ five times for one and a half hours.	0 to ½ for four and a half hours (about).	Zero for two hours.	$\frac{6}{10}$
	,,	,, 12th.	8	9	½ (fully).	2 to 2½ for three-quarters of an hour.	2½	0 to ½ for five and a half hours.	Zero for three and a half hours.	
No. 3.	Helyear "Tropic."	,, 17th.	8	10	$\frac{7}{10}$	1½ for three hours.	1	0 for one and a half hours.	Zero to ½ for four hours.	
	,,	,, 18th.	8	11	½	1½ for one hour.	1½	0 to ½ for four hours (about).	0 for two hours.	$\frac{6}{10}$ (barely)
	,,	,, 19th.	8	12	½ (barely).	1½ for half an hour.	1½	0 to ½ for four hours.	0 for one hour.	
No. 4.	Florence.	,, 23rd.	7	13	½ (fully).	½ to ¾ for one hour.	1	0 to ½ for three and a half hours.	0 for two hours.	
	,,	,, 24th.	7	14	$\frac{5}{10}$ (barely).	,,	1½ for three minutes.	0 to ½ for five hours (about).	0 for three and a half hours.	½ (minimum of all grates).
	,,	,, 25th.	8	15	½ (barely).	½ for one hour.	1 for 20 minutes.	0	0 for five hours.	
No. 5.	Well Fire.	,, 31st.	8	17	1½ (fully).	2 for half an hour.	2	½ for half an hour.	Never zero.	
	,,	August 1st.	8	18	1 (barely).	2 and 2½ for half an hour.	2½	Zero at end of the day for half an hour.	½ for one hour.	1½ (fully).
	,,	,, 2nd.	8	19	1 ,,	1½ for half an hour.	2½	½ for one hour.	0 for one hour.	
No 6.	Smith and Wellstood.	,, 8th.	7½	21	1¾ (barely).	2½ to 3 for three-quarters of an hour.	3; five times 2 to 3.	½ for three-quarters of an hour.	Never quite zero.	
	,,	,, 9th.	8	22	1$\frac{6}{10}$	2½ to 3½ for one hour.	3½	1 for two hours.	,,	1$\frac{6}{10}$ fully (maximums of all grates).
	,,	,, 10th.	8	23	1$\frac{6}{10}$	2½ to 3½ for three-quarters of an hour.	3½	½ for one hour.	,,	

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TABLE III.—*Meteorological Readings (taken daily at 8.30 a.m. by Steward's Instruments).*

Date.	Barometer reduced to sea level and 32° F.	Direction of wind.	Rainfall.	Solar radia in vacuo.	Maximum temperature in the shade.	Minimum temperature.	Remarks at 8.30 A.M.
1901.							
June 27th.	30·29	E.	..	118	74	56	Fine.
„ 28th.	30·15	E.	..	120	75	55	Cloudy.
„ 29th.	30·11	E.N.E.	..	122	76	59	Fine.
July 1st.	29·70	S.W.	0·98	105	73	60	Overcast.
„ 3rd.	29·69	E.	0·15	125	75	58	Cloudy.
„ 4th.	30·02	E.	..	114	75	59	„
„ 5th.	30·09	N.W.	..	125	87	62	Hazy.
„ 10th.	30·05	E.	..	122	85	58	„
„ 11th.	30·09	E.N.E.	..	121	86	59	„
„ 12th.	30·05	S.S.W.	..	113	85	60	Fine.
„ 17th.	30·26	S.	..	129	88	60	„
„ 18th.	30·20	E.	..	124	86	58	Hazy.
„ 19th.	30·10	E.N.E.	..	122	90	63	„
„ 23rd.	29·81	N.W.	..	89	67	58	Raining.
„ 24th.	29·56	S.	0·04	107	68	58	Overcast.
„ 25th.	29·52	S.E.	0·37	107	72	58	Cloudy. *
„ 26th.	29·60	N.	1·60	74	63	57	Overcast.
„ 31st.	30·22	N.	..	119	81	63	Hazy.
August 1st.	30·09	N.	..	116	78	61	Cloudy.
„ 2nd.	30·15	N.N.W.	..	121	78	62	„
„ 3rd.	30·27	S.W.	..	116	75	59	„
„ 8th.	30·02	W.	..	124	78	61	Bright.
„ 9th.	30·00	S.W.	..	122	86	61	„
„ 10th.	29·60	S.E.	..	128	79	65	Cloudy.

* Thunderstorm in London lasted from noon until 4.30 p.m., during which period no less than 1·98 inches of rain were measured in the official gauge at Westminster.

TABLE IV.—*Showing Average Radiation and Rise of Temperature per Pound of Coal per Hour in Degrees Fahrenheit.*

No. of grate.	Average rise of temperature per pound of coal per hour in Degrees Fahrenheit.	Average radiation per pound of coal per hour in degrees Fahrenheit.
1	—	5·82
1a	3·01	5·03
2	3·59	5·99
3	3·63	5·97
4	6·64	9·7
5	3·65	5·87
6	3·57	5·8

13328. With regard to the ordinary cookers, where there is a keen draught the smoke is many times worse than in an ordinary fireplace, is it not?—We have no means of testing cookers.

13329. But I mean the experience of everybody in every kitchener is to that effect. When you have no fires in your house you find half your coal consumption is going on all the time?—Yes, it goes on in the summer.

13330. I should think, with regard to anthracite, there would be a difficulty in its being used, because it would be out of reach for general use?—Yes; we quite recognise that the general use of anthracite is impossible.

13331. I think, if you are going to do any good, you must confine yourselves to the coal which the market has shown is the cheapest?—Yes; as practical men, that is what we have aimed at. We have aimed at the cheapest coal. We know that anthracite is impossible. But, of course, what we feel is that some public department should take up this question; I mean, it is a scandal that cities like the biggest cities of England should submit to a loss in the winter, as we do, of 50 per cent. of our sun-light. We are told by the Meteorological Office that we lose 50 per cent. of our sunlight in the winter.

Dr. Harold A. Des Voeux.

19 Mar. 1903.

13332. (*Mr. Young.*) Can you say whether the grates in the Duke of Wellington's house and those in the Wellington Club are the same?—I cannot tell you at all, because, you see, we never let our Inspector go into any of these premises. That observation with regard to the Duke of Wellington's house is an observation purely of my own, because I ride by there every morning, early, and I watch those two chimneys. The Wellington Club chimneys used to be always smoking, but the City of Westminster came down upon them, and said: "You must stop your chimneys smoking; you are a club." But they cannot say anything to the Duke of Wellington because he has a private house.

13333. I think you said that since the magistrates gave that decision many of the clubs have commenced to emit smoke again considerably?—Yes.

13334. What can be the reason for doing that, seeing that they would have still the same grate as they had before?—I suppose they use cheaper coal again. Of course, you can get over the difficulty by using good coal, and I daresay some of them may have auxiliary gas for cooking, and they may have used their gas for cooking. I cannot say what the reason is.

13335. According to the Tables which you showed us a moment ago they can get very much less smoke at a very much less cost, cannot they?—Yes, but it is very difficult to prove that, and it is very difficult to get it known.

13336. Then are we not to take it that the figures you have there are absolutely reliable?—I think they are absolutely true, but then it is very difficult for a person who is always working through servants to know that, is it not? For instance, take your own house; it is very difficult to know what coal you use and why one servant uses much more coal than another. I know in my own house it is extraordinary what different amounts the different servants will use. But what we feel strongly is that this is a big question which has not been tackled, and that nobody but some central department can properly tackle it; and that we, as a private society, have neither the money nor the influence to tackle it properly.

13337. (*Sir George Armytage.*) Practically, what you mean is this, that there is no authority to inspect or take any interest in the domestic fire grates?—That is so, and, if this question is not tackled, the smoke of a big town like London, which is increasing by 53,000 or 60,000 inhabitants per year, will be gradually becoming more and more serious.

13338. You mean, if there were such an authority to deal with the question there would be greater economy?—I am sure there would be greater economy if the matter were properly taken up by some central authority with sufficient means, with some power behind it.

13339. In measuring the smoke which is emitted, have you some instrument by which it can be done?—No, we have not. Of course, if it were properly done, the smoke should be collected and weighed; if it is of sufficient importance, as we think it is, there is no doubt the smoke should be collected, taken away, and weighed. That would be a perfectly accurate test. The test we have made is a fairly efficient one, but it is a question of the eyesight of one man, who, of course, has been specially trained for the work.

The results of the recent tests referred to by Dr. Des Voeux in Questions 13259 to 13262 were published in detail in the "Lancet" of the 20th February, 1904 (page 529), and in effect they confirm his view that the grates which emit the least smoke are also the most economical in coal consumption. The grates tested were:—

I. The Tropican.
II. Messrs. Landers' Grate.
III. The "Heaped" fire.
IV. The Francombe.

and they were placed by the Jury in order of merit as here given.

The Report states that a distinct advance has been made in the construction of smoke-consuming or smoke-preventing grates, and that a large part of the present smoke nuisance is evidently caused by careless and inefficient stoking.

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TWENTY-SECOND DAY.

Tuesday, 28th April 1903.

PRESENT:

The CHAIRMAN.

Sir GEORGE ARMYTAGE.
Sir LINDSAY WOOD.
Mr. BELL.
Mr. BRACE.
Mr. BRIGGS.
Professor DIXON.
Mr. J. S. DIXON.
Dr. LE NEVE FOSTER.
Professor HULL.
Mr. TEALL.
Mr. YOUNG.

The Secretary.

Dr. BOVERTON REDWOOD, called; and Examined.

Dr. Boverton Redwood.

28 April 1903.

13340. (*Chairman.*) I understand you will be good enough to read the statement you are about to give us. That will shorten matters, and probably put it before us more clearly. You are, as we know, a great authority on questions relating to petroleum. You are Adviser, I understand, on Petroleum to the Home Office?—I am, my Lord.

13341. And Consulting Adviser under the Petroleum Acts to the Corporation of London?—I am.

13342. And you hold a great many other appointments. Now will you kindly give us your statement?—

I.—PETROLEUM AS A FUEL.

(1.) May I be allowed, my Lord and gentlemen, in the first place, to say that, in considering the subject of petroleum as fuel, it should, in my opinion, be borne in mind that petroleum and allied hydrocarbons are used as a source of power otherwise than as a fuel for steam-raising, and in a comprehensive review of the subject it will, therefore, be necessary to deal not merely with the use of mineral oil as a substitute for coal in the furnaces of steam boilers, but also with the employment of petroleum in internal combustion motors of the gas-engine type, though many, in speaking and writing of liquid fuel, appear to ignore the latter application.

(2.) It is true that until recently only certain refined products of petroleum were found suitable for use in internal combustion engines, and that serious doubts were expressed as to whether engines of this type could be successfully employed for high powers. Even now it may be said that the oil engine, as compared with the steam engine, is still in the stage of development, and, although much has been accomplished, it may be confidently predicted that far greater improvements will yet be made.

(3.) In the earlier forms of oil engines a highly volatile description of petroleum, such as the gasoline or benzoline of commerce, was employed, as this evaporates freely at common temperatures, and thus readily furnishes the necessary explosive mixture of hydrocarbon vapour, and air. Such product is now usually employed in the engines of motor cars and motor launches, as well as in submarines, under the name of petrol, or motor spirit. It commonly has a specific gravity of ·680 at 60° F., but a spirit of somewhat higher density has also been used. Engines of this type can also be driven with alcohol or a mixture of alcohol and the coal-tar product, benzol (petroleum is only slightly soluble in alcohol), and in France efforts are being made to encourage the substitution of alcohol for petroleum spirit for this purpose, with a view to benefiting the home industry of alcohol manufacture. One kilo of 90 per cent. (by volume) alcohol is stated to develop 5,500 calories, and 1 kilo of petroleum 10,300 calories, but a much larger percentage of the heat is asserted to be converted into work in the use of alcohol. According to a recent U.S. Consular Report much attention is also being paid to the use of alcohol as a source of power in Russia, and for the past two years the Navy of the Czar has been using alcohol boat motors up to 300 horse-power with highly satisfactory results, the alcohol consumption ranging from 0·45 to 0·5 litre per horse-power hour. In Great Britain the fiscal conditions preclude such use.

(4.) For stationary engines, and especially those of large power, ordinary kerosene (petroleum or paraffin oil), such as is burned in lamps, has long since replaced petroleum spirit, the difficulties which were at first experienced in the use of this volatile product having been successfully overcome by the adoption of devices for spraying and vaporising by heat. Engines of this type, commonly called heavy oil engines to distinguish them from the petrol engines already referred to, are the Priestman, Hornsby-Ackroyd, Crossley, and others. They are largely employed, and their use is rapidly extending.

(5.) Recently attention has been directed to an oil engine invented by Mr. Diesel, in which, among other features of novelty, the oil is injected into the charge of air, which is subjected to such high compression that its temperature is raised to the point of incandescence, and in these circumstances it has been found that a very heavy oil and even crude petroleum can be successfully employed as fuel.

It therefore follows that by means of suitable appliances any description of petroleum products or crude petroleum itself can be thus made available as a source of power.

(6.) Concurrently, by the introduction of various improvements in design, it has been found practicable to overcome the difficulties at first experienced in constructing oil engines of large size, and such engines are now made of very considerable horse-power.

The importance of this advance will be readily appreciated if it is borne in mind that in steam engines of moderate dimensions only 12 per cent. of the total heat given to the boiler in the form of coal appears in the engine as indicated work, whereas in gas or oil engines the proportion of heat rendered effective is in some cases more than double the above percentage.

Experiments made by Professor Unwin showed that with a Priestman Engine the consumption of ordinary kerosene was 0·842 lb. per brake h.p. per hour. The usual experience with petroleum spirit engines on motor cars is that the consumption amounts to about 7 lbs. of petrol per hour for 10 brake h.p., though some engines are claimed to exhibit a far higher efficiency than this. The railway motor cars now being constructed for use by the North-Eastern Railway Company between the two Hartlepools are furnished with engines of 95 brake horse-power, and are expected to run for seven hours with a consumption of 30 gallons of spirit.

(7.) Many engineers of eminence have even ventured to predict that in course of time the steam engine will be superseded by the oil engine, although as yet no attempt has been made to introduce internal combustion engines for the propulsion of large ships, and it is only quite recently that it has been thought practicable under modified conditions to employ such engines for railway use. It is reported that the Russian Ministry of Marine have recently given instructions for a torpedo boat destroyer of 350 tons' displacement to be fitted with a naphtha motor engine of 6,000 indicated horse-power.

It is evident that on the basis of our existing experience there is scope for the advantageous employment of oil engines as substitutes for the very large number of independent steam engines of moderate power required for the working of the machinery on our ships of war.

(8.) In considering the subject of the use of petroleum in internal combustion engines it should be borne in mind that petroleum is now largely employed by the gas companies, in conjunction with water gas, as a substitute

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for coal, and that many gas engines are therefore being partially, and some wholly, driven by gasified petroleum.

(9.) A brief reference should be made to the success which has attended the use in small engines for motor launches of petroleum spirit as the evaporating agent in place of water, the vapour of the spirit being employed expansively in an ordinary steam engine and subsequently condensed. Alcohol is similarly used.

(10.) For high powers on land and water, as well as for railway traction, petroleum has for many years been used most effectively and economically as a substitute for solid fuel in steam-raising, especially in Southern Russia, and this application of petroleum is rapidly extending wherever supplies can be obtained at a cost not exceeding double that of steam coal in the locality at the time. The pioneer in the use of petroleum on locomotives in Russia was Mr. Thomas Urquhart, and as this gentleman is to be called to give evidence I will leave him to report the results he obtained. In this country Mr James Holden, the locomotive superintendent of the Great Eastern Railway, has led the way in the adoption of liquid fuel, and has devised an excellent system of combustion which he will, I presume, explain to the Commission.

(11.) For use on steamships the advantages presented by liquid fuel are very marked. No one who has travelled on an oil-burning steamer on the Caspian Sea (where no other fuel is employed) can have failed to be struck with the saving in labour of stoking and the effectiveness of control, whilst the ease and celerity with which the bunkers can be replenished constitute additional grounds for the preference given to this fuel. Weight for weight, liquid fuel occupies rather less space than coal, and when effectively burned has almost double the calorific value, though this advantage has not been fully realised in practice in marine boilers.

(12.) For some purposes, as, for instance, for domestic use, liquid fuel is not a convenient heating agent, and accordingly many processes have been from time to time suggested for the so-called solidification of petroleum with a view to its conversion into a solid fuel. Twelve years ago I had occasion to report upon a process patented by Chenhall & Chenhall, which consisted in heating together a suitable description of petroleum resin, and soda, a solid compound being thus obtained which contained about 75 per cent. by weight of petroleum and burned without liquefying.

About the same time J. H. W. Stringfellow proposed to use quillaia bark to convert petroleum into a semi-solid or jelly-like substance. The solidifying action on petroleum of a decoction of quillaia or saponaria had been pointed out previously (viz., in 1875) by Morgan-Brown, who patented a process based upon it in that year. The similar employment of an extract of a lichen, such as Japanese, Chinese or Corsican moss, was patented in 1879, and among other solidifying agents since then proposed are fish glue and casein.

Within the past few years I have been called upon to devote some time to the supervision of practical tests of the Leadbeater patent process for the conversion of petroleum into solid fuel. The inventor takes 128 parts by weight of petroleum and incorporates with this one part of stearine, 12 parts of rosin, eight parts of sawdust, and eight parts of unslaked lime (the sawdust furnishing sufficient water for the chemical reaction). He thus obtains a solid compound which can with great advantage be employed as an ingredient in a coal briquette.

Quite recently my attention has been called to a briquette made by Mr. Hartridge, in which a similar petroleum compound is used in conjunction with straw and coal in the proportion of 25 per cent. by weight of the solidified petroleum, 3 per cent. of straw, and 72 per cent. of coal. I am informed that a briquette containing 35 to 40 per cent., or even as much as 50 per cent. of petroleum can thus be made. I ventured to bring with me, my Lord, a specimen of this fuel in order that the members of the Commission can see the sort of material which is produced in that fashion. (*The witness produced sample.*) That particular sample contains 35 per cent. of Russian petroleum or residuum ostatki.

13343. Is this made in Russia?—No, that has been made in this country by the process to which I have just referred, a process dependent for its action upon the solidifying effect of rosin, stearine, and lime.

13344. Is it made on commercial principles?—At present not; it is only a quite recently patented process. The inventor attaches a great deal of importance to the use of straw; he takes straw and arranges the stems parallel or roughly parallel, and, passing them through a machine, knits them together, and in that way forms a continuous band which is caused to travel through the petroleum compound while the latter is in a liquid condition; and then the coal dust is added and the band passes on through a series of rollers which gradually compress it; it is thus brought into this form.

13345. The straw is used as a tie?—It is used as a carrying material for the petroleum compound first, and then as a binding agent, keeping the briquette together.

(13.) The petroleum product, which is chiefly used in Russia as fuel, is known as ostatki (often erroneously written "astatki"). This is the residue which remains in the still after the benzine and kerosene have been distilled off, and it sometimes has a flash point as high as 300° Fahrenheit (close test). In the early days of the Russian petroleum industry ostatki was an almost worthless bye-product, necessarily obtained in the manufacture of kerosene or refined oil for use in lamps, and although every effort was made to separate as much of the lighter hydrocarbons as possible, it represented from 60 to 70 per cent. of the crude oil. When the value of ostatki as fuel became recognised, the conditions were speedily altered; the residue became the important product and the distilled oil the bye-product, with the result that the aim of the refiner was thenceforth to make as little of the latter as possible consistently with the production of ostatki of suitable character, and the Russian petroleum industry may therefore be said to have long ago become a great fuel industry.

(14.) Where considerations of safety in respect of storage, transport, and handling may be ignored, there is no difficulty in burning the crude oil as fuel, and accordingly this is commonly done in the oilfields, not only in Russia, but generally. Moreover, in some of the Baku refineries the benzine, which cannot be readily sold, is used as fuel. For ordinary purposes, and especially for employment on passenger steamships, it is no doubt desirable to have a liquid fuel which does not readily ignite or give off inflammable vapour at any temperature to which it is likely to be subjected before it enters the burner, and accordingly standards of flash point for such oil have been fixed.

(15.) The limitation of flash point is a matter of importance, for it is evident that the higher the standard the more restricted the available supplies. Safety in storage, transport, and use must be the first consideration, but the limit of flash point should be as low as is consistent with this. On the Russian railways the minimum standard is, I believe, 70° C. (158° F.), by the Abel-Pensky close test, but in this country a disposition to exact a higher standard, at any rate for marine work, has been exhibited. As regards transport and storage it cannot, I consider, be contended that a standard of 150° F. (close test) is insufficiently high. In use on board ship, if leakage occurs in the stokehole, no practicable limit of flash point, however high, would render the oil safe, but leakage can and should be guarded against, and if escape of oil does not occur a standard of 150° F. may be regarded as adequate. Any unnecessary requirement as to flash point would tend to make liquid fuel more costly, and would diminish the supply. In California, where the use as fuel of the oil produced in that State is increasing rapidly, it is generally considered that a flash point of 150° F. is high enough, and in India the import duty on petroleum having a flash point not below 150° F. has been reduced to 5 per cent. on proof being furnished that the oil is intended to be used exclusively as fuel.

13346. Reduced to 5 per cent.?—Reduced to 5 per cent.; it is much higher in the case of other products.

(16.) The combustion of fuel oil for steam raising is usually effected by spraying or atomising it by means of specially constructed burners which are inserted into the fire-door of the furnace. The action of these burners is similar in principle to that of the perfume vaporiser worked by a stream of compressed air travelling horizontally across the orifice of a vertical tube communicating with the liquid perfume; but the spraying agent is usually steam, though air is sometimes used, and the steam or air and oil supply tubes are arranged concentrically. For marine use especially the steam atomiser is open to the objection that a considerable amount of steam is lost, and this involves the use of an evaporator to make up for the loss of water. Recently a form of liquid fuel burner, of which this is one (*the witness*

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Dr. Boverton Redwood.

28 April 1903.

produced burner), in which the oil is sprayed by being forced at high pressure through a very small orifice against a steel knife hedge, has been tested at the Baltic Shipbuilding Yard and elsewhere in Russia with satisfactory results. The burner works well with an oil pressure of about 60lbs. per square inch, but better results are obtained with higher pressures up to as much as 300 lbs., though the burner is then somewhat noisy. The oil is supplied to this form of burner by means of a pump, and passes on its way to the burner through a strainer or filter whereby any solid particles which might choke the jet are arrested, and the burner is fitted with a needle-pointed rod which by means of a screw can be driven into the jet for the purpose of clearing it. As a pump is necessarily used, the supply of oil can be carried in tanks below the level of the burner. You will see, my Lord, that that screw at the end actuates a needle-pointed rod which can be driven into the little jet at the other end, the end you are now looking at, so as to clear it if any obstruction should occur. In the use of the burner there issues from that small orifice a stream of oil under high pressure which, impinging upon that knife-edge, becomes converted into fine spray.

(17). Apart from the use of petroleum in internal combustion engines, which on the score of comparative economy may be expected to be very largely extended (though only gradually as regards high powers) as improvements are made in such motors, it may be said that at the present time in all civilised countries there is a general recognition of the merits of liquid fuel for steam generation and furnace work generally, including such operations as cement manufacture and glass-making, and that nothing but the assurance that adequate supplies will be continuously available is needed. Hitherto, or until recently, the liquid fuel industry has been an offshoot of, or the outcome of, the pre-existing industry of the manufacture of the ordinary commercial products of petroleum, and deposits of petroleum not yielding the latter products in sufficient quantities have been regarded as comparatively valueless and have remained unworked. This has been notably the case in the United States, but within the last few years there has been a largely increasing output of fuel oil in California, and the copious yield for a short time given by the flowing wells or so-called gushes on Spindle Top in South-Eastern Texas raised hopes that very considerable supplies would be obtainable in a district most conveniently situated for export. This has unquestionably contributed materially to direct public attention to the liquid fuel question, but so far these anticipations have not been realised, for the cessation of flow of the gushers has brought about such a rise of price as prohibits delivery to this country in competition with coal, and until further producing areas in this State are developed America may be expected to use all the Texas fuel oil that can be produced.

It, however, by no means follows that the Texas wells will have flowed in vain, for it may be hoped that interest in the subject having been aroused, other known sources of supply of oil suitable for fuel may be brought into development. There has been too much disposition for the potential producer of such oil to postpone operations until there was an assured market for it, and on the other hand for the fuel user to apathetically await the creation of adequate supplies.

II.—Present and Prospective Sources of Supply of Petroleum and Allied Products.

(18). We come now, my Lord, to a second division of the subject, namely, the present and prospective sources of supply of petroleum and allied products. As is well known, the chief supplies of petroleum are contributed by the United States and Russia, and the relative importance of other sources of present supplies is indicated by this tabular statement of the world's production, in the compilation of which I have been assisted by my colleague, Mr. Eastlake.

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Dr. Boverton Redwood.

28 April 1902.

TABLE A.

World's Production of Petroleum for 1901 in Imperial Gallons.

Country.	—	Quantity.	Percentage of Total.
Russia:			
Baku Field	2,786,182,280		
Grozni Field	142,213,010		
		2,928,395,290	50·9619
United States:			
* Appalachian Field	1,176,165,328		
Lima-Indiana Field	767,361,197		
California	307,398,541		
Texas	153,716,518		
Colorado	16,111,752		
Kansas	6,267,776		
† Missouri	431,552		
Wyoming	188,924		
Illinois	8,746		
		2,427,650,334	42·2480
Galicia	—	117,979,782	2·0532
Eastern Archipelago:			
‡ Sumatra	70,696,210		
‡ Java	21,446,418		
‡ Borneo	14,169,330		
		106,311,958	1·8501
Roumania	—	50,658,525	·8816
India:			
Burma	49,441,734		
Assam	631,571		
Punjab	1,812		
		50,075,117	·8714
‡Japan	—	25,502,168	·4438
Canada	—	24,670,520	·4293
Germany:			
§ Hanover	5,940,716		
Elsass	4,860,697		
		10,801,413	·1879
Peru	—	2,611,455	·0454
Hungary	—	854,873	·0014
Italy	—	618,947	·0010
Barbados	—	7,200	·0001
United Kingdom	—	1,991	·0000
		5,746,139,573	99·9751

* The Appalachian field comprises New York, Pennsylvania, West Virginia, South-eastern Ohio, Kentucky and Tennessee.
† Includes the production of Michigan, Indian Territory, and the small yield obtained in Oklahoma Territory.
‡ Estimated.
§ Includes the small production obtained in Bavaria.

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Dr. Boverton Redwood.

28 April 1903.

On reference to Table A. it will be seen that Galicia (Austria-Hungary), the Eastern Archipelago (Sumatra, Java, and Borneo), India (chiefly Burma and Assam), Roumania, Japan, Canada, Germany (Hanover and Elsass), Peru, and to a small extent Hungary, Barbados, and the United Kingdom, are also contributors, in the order of importance in which they are given, of amounts which in the aggregate are not small.

In regard to this table, I wish to say that although considerable labour has been devoted to the collection and verification of the figures given, and official records have as far as possible been consulted, the stated production must in some instances be regarded as only an approximate estimate. The figures for Russia and the United States are probably fairly exact, but in respect of Galicia and Roumania they are doubtless lower than the actual output, owing to the circumstance that fiscal considerations often lead to the production being understated. The producers, in point of fact, have to pay a very heavy Government tax upon the quantity of oil raised, which leads them in many instances to officially understate, and largely understate the actual output. Moreover, oil used as fuel in the business is sometimes not allowed for. Taking all this into account, it may safely be said that the aggregate production exceeds the total given, especially as a certain amount of oil is known to be collected in localities hereafter to be referred to which is not included, as no trustworthy record or estimate of the quantity is obtainable.

Some idea of the magnitude of the world's consumption of petroleum may be given by the statement that for the storage of a year's supply a rectangular cistern about 2½ times the height of St. Paul's Cathedral, and of a similar length and breadth, would be needed. As a matter of fact, the receptacle would have to be a 973ft. cube.

(19). In addition there is a production of mineral oil from shale in Scotland, New South Wales, and New Zealand, as shown in the following statement:—

Production of Oil Shale in Statute Tons.

	1901.
United Kingdom - - - - -	2,354,356
Australia (N.S.W.) - - - - -	54,774
New Zealand - - - - -	12,048

Those are the figures for 1901, which is the latest year for which I have obtained accurate figures.

(20). America.—In the United States there was during the year 1901 (the latest for which complete official statistics are available) some falling off in the yield of the older fields, situated in New York, Pennsylvania, West Virginia, Kentucky, Tennessee, and the south-eastern portion of Ohio, but this was more than balanced by a great increase in the production of Texas and California. The oil obtained in the newer fields is, rom the point of view of the refiner, of inferior quality, as it yields less of the ordinary commercial products, but it is suitable for use as fuel, either as it comes from the wells, or after the separation of some of its more volatile constituents, and is being largely used as a substitute for coal in the south-western and western sections of the country. The average yield of the usual products from 100 gallons of Pennsylvania crude oil is 11 gallons of gasoline and other grades of petroleum spirit, 76 gallons of burning oil (kerosene), and 3 gallons of lubricating oils, the remaining 10 gallons representing residuum and loss.

Other States besides those mentioned which contributed to the supplies in 1901 were Ohio (Lima and Mecca-Belden districts), Indiana, Colorado, Kansas, Indian Territory, Michigan, Missouri, Oklahoma Territory, Wyoming, and Illinois.

Of the burning oil exported from the United States this country (Great Britain) takes over 30 per cent., Germany about 25 per cent., and the Netherlands about 32 per cent. France very largely imports the crued oil and refines it in the country.

In many of the States which have only within recent years assumed importance in respect of petroleum production, there is undoubtedly scope for enormous increase in output. The petroleum of California is very largely a fuel oil, and its use as such is exercising a most important effect locally in bringing about the establishment of various manufacturing industries.

The fuel oil of Texas has already been referred to, and it only remains to be added that the proximity of the oil fields of this State to the seaboard will undoubtedly stimulate search for further producing areas.

In Wyoming there is a vast area of territory presenting the most promising indications, and in one district spouting wells have already been drilled.

(21). Russia.—Although the petroleum production of Russia somewhat exceeds that of the United States, its importance to foreign consumers is not in proportion, owing to so large an amount of the oil (about two-thirds of the output of the wells) being used in the country as fuel. The two centres of production are the Baku district on the Caspian Sea and the Grozni field in the Northern Caucasus. The territory is in both localities remarkably rich, and the wells can not only be without disadvantage drilled nearer together than in America, but in addition the yield from a given number of wells in Russia is far larger than it is in America, though it should be added that the Russian wells are more costly. The present developed area of oil-bearing lands in Russia is only a few square miles, and there is no doubt practically unlimited scope for extension as excellent indications occur at widely separated points. Some attempts have been made to develop known deposits on or near the Black Sea, and very promising results have been obtained. The completion of a number of largely productive wells on the Black Sea could not fail to have an important effect on the industry, for at the present time the cost of conveyance of petroleum products from Baku or Grozni constitutes a serious addition to the selling price in the markets of Western Europe and Eastern countries. A pipe-line from Baku to the Black Sea has long been in course of construction, and is expected to be completed within a few months' time, but this is only for kerosene. Lack of transport facilities is the great difficulty which the Russian petroleum producer is confronted with, and until this is removed there will probably not be any large extension of the fuel oil business in that country.

13347. Does that mean transport facilities from the point of production, say, to the coast?—Yes, that is so, my Lord. Perhaps on that point I had better say that at present the only means of transporting to the Black Sea any product of petroleum available for fuel is by means of tank cars on the Baku-Batoum Railway, and although that line has since its original construction been improved by the making of the Suram Tunnel, still the gradients are very heavy, and the cost of transport over that 600 miles of railway is necessarily high, so that practically it is at the present time a matter of impossibility for an importer to purchase Russian fuel oil in Baku and ship it on the Black Sea with a view to its transport to this country or to Europe.

13348. Has anything been done in the way of pipe-lines?—Only as far as regards the transport of the kerosene—refined oil. I should perhaps explain that there has been considerable opposition on the part of the Russian petroleum trade to the construction of a pipe-line for crude oil between Baku and the Black Sea, for the reason that very large amounts of money have been invested in refineries at Baku, and it is recognised that if any adequate facilities were provided for the transport of crude oil from Baku to the Black Sea the effect would be to largely transfer the refining industry from Baku to the Black Sea, and in that way to render comparatively valueless the present Baku refineries, so that the great firms have consistently opposed the construction of a pipe-line for crude oil between Baku and the Black Sea.

13349. But that is an opposition which comes practically from the producers of the oil?—It is, but it is an opposition which is dictated by what they conceive to be their interests in the conservation of the property that they already hold.

13350. (*Mr. Young.*) Have those firms a charter or some agreement which gives them power to prevent the Government giving a concession to anyone for a pipe-line?—The Government, I may say, have no disposition at the present time to give the necessary charter for a pipe-line, because the Baku-Batoum railway is a Government-owned line, and it depends for its income very largely upon the transport of petroleum. Therefore, the Russian Government say in effect this: If we are to give the right to construct a pipe-line we must have a guarantee that will cover us for any loss of revenue on the income that we make at the present time by the transport of petroleum.

(22). Galicia—Until within quite recent years the oil-fields of Galicia, which extend for a distance of over 200 miles along the northern slopes of the Carpathian

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mountains, were not able to fully supply the requirements of Austria-Hungary, but lately very productive lands have been brought into development in Boryslaw, and the production is in excess of the home consumption. There is scope for considerable further increase in output if arrangements can be made for an export trade.

(23). Eastern Archipelago.—In Sumatra petroleum is found in the State of Langkat, at the northern end of the island, opposite the Straits of Malacca; in the neighbourhood of Palembang, near the northern shore of the south-eastern end of the island, and elsewhere. Much of the petroleum of Sumatra contains an unusually large proportion of the more volatile hydrocarbons. In Java petroleum occurs in many places, but has been chiefly worked near Sourabaya, in the north-east. The petroleum of Java contains a large amount of solid hydrocarbons (paraffin). There are indications of the existence of petroleum in several widely separated localities in Borneo, but it is only in Kotei, in Eastern Borneo, that there has so far been any production. Most of the oil hitherto found has been heavy and better suited for use as liquid fuel than for other purposes.

(24). India.—In Burmah British enterprise has been conspicuously successful in completely transforming the primitive mode of working which existed in the days of Theebaw, and creating an industry which, already of great importance, is in a condition of vigorous growth, and is doubtless destined to expand to far larger dimensions. The area of oil-bearing territory already developed by the Burmah Oil Company is very considerable, but there is good reason to believe that it will be largely added to as the result of the exploratory work which is being systematically and energetically carried out by this company. It is satisfactory to find that this spirited policy is receiving the well-merited support of the Government. In Assam, another British company, the Assam Oil Company has already laid the foundation of a most promising business. A small quantity is also collected in the Punjab.

(25). Roumania.—The petroleum deposits of this country are continuous with those of Galicia and occur on the slopes of the mountain range from the Galician frontier to the Iron Gate, a distance of about 400 miles. In many localities, but notably at Campina and Bustenari, a large production is assured, and on some of the properties highly productive flowing wells exist. The commencement of an export trade has been made, and only adequate transport facilities are needed for the extension of this branch of the business which the favourable geographical position of the fields renders possible.

(26). Japan.—The petroleum industry of Japan has already assumed important proportions, and it is in a condition of active growth. The chief supplies at present come from the province of Echigo.

13351. (*Chairman.*) Is that on the coast?—It is not far from the coast—on the north-west coast, near the centre of the main island of Nippon, but there are other localities where petroleum is found.

(27). Canada.—The petroleum industry of Canada is of considerable age, but has not expanded within recent years. The production is obtained mainly in the neighbourhood of Petrolia and Oil Springs in the Lambton district, in the south-west part of the Province of Ontario. As a rule, the yield of the wells is small.

13352. (*Professor Dixon.*) Is there any petroleum being worked at Gaspé in Canada?—A great deal of drilling has been done at Gaspé; the wells had to be carried to a depth of over 3,000ft. before any oil was found, and although the oil, as I know from having examined many samples of it, is of excellent quality, I am afraid the quantity available is very small, and not such as to pay a fair return upon the high cost of drilling a well to such depth as 3,000ft.

(28). Germany.—Petroleum is produced in Germany near Celle, in Hanover, and in Elsass; also to a small extent in Bavaria. The crude oil of Elsass is of high specific gravity, and does not yield a large proportion of kerosene, whilst that of Hanover is of still greater density.

(29). Peru.—There are in Peru three petroliferous districts, the Northern (Zorritos), the Central (Talara, on the west coast), and the Southern (in the Province of Piura). The present production is obtained at Zorritos and Talara.

(30). Hungary.—The production in this country, although still small, has considerably increased within the past two years. *Dr. Boverton Redwood.* 28 April 1903.

(31). Italy.—In this country petroleum occurs in many localities, though it is commercially worked only in the Milan district, and the production is but small.

(32). Barbados.—Petroleum is now being obtained by an English company (the West Indian Petroleum Company) in the Scotland district.

(33.) United Kingdom.—Crude petroleum cannot be said to be produced in this country, but small quantities are obtained in North Staffordshire and elsewhere. The figure is in the table which has been put in.

OTHER POSSIBLE SOURCES OF SUPPLY.

(34).—Having now dealt with the producing countries included in the tabular statement of the world's production of petroleum it will be instructive to review briefly those localities in which, although at present there is no commercial production, supplies may probably be obtained, and in doing so it may be preferable to consider first those which are within the British Empire.

(35). India.—It has been already stated that considerable extension of the present producing area in Upper Burmah may be looked for, for there is no doubt that in this district and in Assam there is ample scope for very large increase in production. Petroleum has also been found in some quantity by drilling in the Khatan Valley in Baluchistan, and occurs not only in the Punjab, where, as we have seen, a little is now collected, but also in Lower Burmah.

(36). Canada (North-West Territories).—In the district drained by the Peace and Athabasca rivers, which lies to the north of the territories of Alberta and Saskatchewan, there is an immense region presenting very promising indications of the existence of petroleum. The "tar sands," of which great areas exist, may be described as a soft sandstone containing bitumen derived from the subjacent limestones, sometimes in such quantity as to make the whole mass more or less plastic. The following calculation, which was given in the summary reports of the operations of the Geological Survey of Canada for the years 1888 and 1889, gives some idea of the enormous outflow of bituminous substances which has taken place in this region. A specimen of the tar sands was found to contain 14·59 pounds of bitumen in a cubic foot, or 22·9 per cent. in bulk. Taking the area at 1,000 square miles, and the thickness at 150ft., there are 28·4 cubic miles of "bituminous sands in sight," and on the basis of the analysis the bitumen amounts to 6·5 cubic miles, or by weight approximately 4,700,000,000 tons. The very much larger quantity of petroleum which must have issued from the underlying limestones to produce this bitumen cannot be estimated, as the nature of the oil and the conditions of oxidation are not known, but it is evident that there must have been here an upwelling of petroleum on a vast scale, probably without parallel elsewhere in the world. Whether the rocks in this region have parted with their stores of oil, and all the more volatile hydrocarbons have been lost by evaporation, or whether effectively preserved deposits underlying impervious cover-rock may be found, can only be proved by boring. Some work has already been done in this direction, but without any very satisfactory results. The occurrence of natural gas in the district is a hopeful feature justifying the continuance of exploratory drilling. Even if oil should not be found in quantity it is probable that the tar sands will be utilised when the region is reached by railways.

(37). New Brunswick.—A petroliferous formation is stated to extend through this province in a general south-easterly and north-westerly direction. Fourteen wells are reported to have been sunk by the New Brunswick Petroleum Company to what is described as the first oil-sand at a depth of 400 to 500 feet.

(38). Nova Scotia.—Indications of the existence of petroleum occur at Cheverie, Hants County, and at Lake Ainslie, Cape Breton. Some test drilling has been carried out without much success, but as experts have expressed the opinion that large supplies may be obtained the work will probably be continued. Exploration at Macadam's Lake, on the north side of East Bay, has shown the existence of a number of beds of shale reported to yield from 15 to 20 gallons of oil to the ton.

(39). Newfoundland.—There is an area of probably 250 square miles of petroliferous territory extending along the west coast of this island, between the sea and the

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Dr. Boverton Redwood.

28 April 1903.

range of mountains running parallel to it. At several points drilling operations have been carried out, and oil has been found in some quantity.

(40). Alaska.—Near Kayak Island, about 360 miles from Sitka, a large area has been found to present good evidence of being richly oil-bearing.*

13353. (*Chairman.*) You have got right to the other side?—Yes; and a well drilled on these lands began to flow when a depth of only 350ft. had been reached. The crude oil yields 24 per cent. of benzine and 54 per cent. of kerosene. It therefore evidently comes from what we should describe as a well preserved deposit, and I am very hopeful of that district. There are other districts presumably oil-bearing on the coast of Alaska.

(41). South Africa.—Traces of petroleum have been observed in the Carnarvon, Fraserburg and Calvinia districts in Cape Colony; but by some these are considered to be probably due to the action of heat on bituminous matter derived from the Lower Karoo Shales, and if this is so they must not be taken as evidence of the occurrence of a workable deposit. A little exploratory drilling has been carried out in South Africa, and more is in contemplation, in view of the great importance which the discovery of petroleum in quantity would possess. At Paardeplaats, near Middleburg, in the Transvaal, a seam of oil-shale, yielding 26 gallons of oil to the ton, occurs over a large area at a moderate depth.

(42). West Coast of Africa.—Very promising surface indications of the existence of petroleum have been met with in the kingdom of Appolonia, about 40 miles from Axim. Boring operations were carried out a few years ago between Adjubansu and Aboaso, and an oil suitable for use as fuel was found at no great depth. Drilling is now being conducted in this district by the West Coast of Africa Oil and Fuel Company, and it is contemplated to use the oil as fuel in connection with the gold-mining industry of that country.

(43). West Indies.—The production of petroleum in Barbados has been mentioned. The celebrated pitch lake of Trinidad, from which over 150,000 tons of bitumen are annually shipped, is evidence that conditions favourable to the formation of petroleum existed here. It is reported that wells are now being drilled for oil a little to the north of the pitch lake, and at Guayaguayare, in the south-eastern corner of the island. The wells in the latter district are expected to be richer than the others, but no great quantity of oil has yet been raised. Petroleum also occurs in San Domingo, and the asphalt of Cuba is an article of commerce.

(44). New Zealand.—Some oil of excellent quantity has been obtained by drilling at New Plymouth, Taranaki district (North Island)—quite on the edge of the water—but a number of borings put down in the Poverty Bay district by the South Pacific Company in 1874, and by the Southern Cross Company in 1881, were unproductive, though shows of oil and gas were met with. Some beds of kerosene shale, one of 31ft. in thickness, were drilled through. The New Zealand Coal and Oil Company are now working a deposit of shale at Orepuki, which yields 35 gallons of oil to the ton.

(45). Australia.—The shale already referred to is mined at Joadja Creek, Mittagong, New South Wales, by the Australian Kerosene Oil and Mineral Company. It resembles cannel coal, and contains about 80 per cent. of volatile matter, with very little sulphur. It yields about 15,000 cubic feet per ton of gas of about 50 candle power, and is used as an enriching material in coal-gas manufacture. In the Warren and Donnelly districts in West Australia, on the stretch of coast facing the south-west, between Cape Leeuwin upon the west and Point d'Entrecasteaux on the east, asphalt and traces of petroleum are said to have been found, but in the opinion of the Government geologist the indications are not such as to justify boring operations. Some years ago a well was drilled on the Coorong, in South Australia, where the substance known as coorongite (which some people say is a bituminous substance and others not) occurs, but not a trace of oil was found.

(46). Great Britain.—The Scottish shale oil industry has already been referred to. The shale at present distilled is mined chiefly in Midlothian and Linlithgow, and yields about 30 gallons of oil to the ton. At one time shale was also distilled to some extent in Wales. Attempts have been made to establish an industry in Ireland by the manufacture of oils from peat by destructive distillation.

The belt of Kimmeridge clay, extending from Abbotsbury to Kimmeridge, in Dorsetshire, contains a vast quantity of bituminous shale, seams of which, locally known as "Blackstone" and "Bubbicum," were worked near the village of Kimmeridge as early as the sixteenth century. On a proved area of between 300 and 400 acres there has been estimated to be over 1,500,000 tons of shale, yielding about 50 gallons of oil and 38 lbs. of sulphate of ammonia to the ton. There are no adequate data for calculating the quantity of shale in the district generally, but it is evident that it must be immense, and it is probable that this shale could be mined and distilled at such cost, that, taking into account the profit on the sulphate of ammonia, the oil could be sold as liquid fuel in competition with coal, though it should be added that the oil has an offensive odour, and is difficult to refine.

Petroleum occurs to a small extent with coal in Lancashire, North Staffordshire, Shropshire and Derbyshire; it has also been found in still smaller quantities elsewhere in England. It is not necessary to refer here to the occurrence of natural gas at Heathfield.

(47). Egypt.—At Gebel Zeit and Gemseh, on the western shore of the Red Sea, petroleum indications have been observed, and in the former locality two wells were drilled in 1884. The first was reported to have yielded about 25 barrels of oil a day at a depth of only 106ft. and the second was a flowing well, for at a depth of 137ft. "a copious stream of mixed oil and water overflowed the top of the pipe." No accurate measurement of the yield was apparently taken, but the outflow was estimated to amount to about 500 cubic metres a day, of which one-third was oil and two-thirds water. Colonel Ardagh, in commenting on these wells, expressed the following opinion: "There is every reason to believe that the Gebel Zeit oilfield contains petroleum in such quantity as to insure the commercial success of those who undertake to work it." Petroleum is also said to occur near Alexandretta.

(48). Turkey.—Oil springs occur at Mendeli on the Turko-Persian frontier, at Hit on the Euphrates, at Kiara on the Tigris, and elsewhere in Mesopotamia.

Petroleum has also been found on the territory extending along the sea-coast from Sharkoi to Hora, in the province of Gallipoli.

(49). Persia.—Petroleum is known to occur in many localities along a line extending in a general south-easterly direction from the Turko-Persian frontier near Kasr-i-Shirin, through Shuster to the Persian Gulf, a distance of about 400 miles. It has been collected in a primitive fashion from the earliest times of which there are any records, and Persian naphtha was an article of commerce nearly half a century ago. A little drilling work was carried out some years ago at Daliki, and on Kishm Island by the Persian Bank Mining Rights Corporation, but without definite results. A concession has recently been granted to Mr. W. K. D'Arcy for petroleum prospecting in Persia, and boring operations are now in active progress at Chiah Sourkh, about 100 miles north of Bagdad.

(50). Algeria.—The existence of petroleum in commercial quantities has been proved by wells drilled near St. Aimé, in the Arrondissement of Mostaganem, Department of Oran.

(51). Zante.—In the island of Zante, near the pitch spring described by Herodotus, which still exists, some boring has been done, and a small yield of heavy oil obtained.

(52). France.—Petroleum has not been found in quantity in France, though indications of its existence are said to occur at Clermont-Ferrand and Grenoble, but there is at Buxières and elsewhere a shale-oil industry of some importance.

(53). Spain.—Petroleum has been found in small quantity at Huidobro, about 30 miles north of Burgos, and at Conil, near Cadiz, but borings made in the latter district were unproductive.

(54). Servia.—Large deposits of shale, yielding 43½ to 45½ gallons of oil to the ton, occur in Servia, near Alexinatz.

(55). Saxony.—Lignite is to some extent distilled for oil in Saxony.

(56). Mexico.—In the States of Tabasco, Oaxaca, and Vera Cruz petroleum springs have been found. Several productive wells are said to have been drilled about 40 miles west of Tampico, and a flowing well has been sunk

*On the 1st of January, 1904, Dr. Redwood wrote as follows:—The coastal oil deposits at Alaska, to which I called attention, are in U.S. territory, but what I had in my mind was that oil may not improbably also be found on the British side of the demarcation line, which is not very far distant.

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in the Vera Cruz district. Petroleum also occurs in the isthmus of Tehuantepec, and is reported to have been found on the isthmus of Panama.

(57.) Colombia.—In the United States of Colombia, near the Rio Arboletes, there are many petroleum springs, from one of which enough oil is said to flow to fill a six-inch pipe. According to a measurement made in 1873 there is at one point an outflow at the rate of over two barrels a minute.

(58.) Ecuador.—The petroliferous territory at Santa Elena, about 125 miles south-east of the port of Guayaquil, has been favourably reported upon, but it has not been developed.

(59.) Argentine.—Drilling was carried on with some success near Mendosa between 1889 and 1893, and for a time the oil obtained was used as fuel on the Argentine Great Western Railway.

(60.) Brazil.—Petroleum is not known to occur in Brazil, but in the Camamu basin, in the Province of Bahia, there are large deposits of a bituminous mineral known as "turfa," which yields from 55 to 60 gallons of oil to the ton, and on the coast near Maceio there are extensive beds of shale yielding about 45 gallons of oil to the ton.

(61.) Timor.—In addition to Sumatra, Java and Borneo, Timor should be mentioned as oil-bearing, for from a borehole made by hand-power to a depth of only 35ft. in a locality where a surface outflow had been noticed, from 2,000 to 3,000 gallons of a crude oil of remarkably good quality were collected.

(62.) Philippine Islands.—Petroleum has been obtained by drilling on Cebu, and has been found on several of the other islands of this group.

(63.) China.—The wells drilled for brine in the province of Se Tchuan yield some petroleum, and it seems highly probable that wells drilled for petroleum in suitable positions might yield largely.

(64.) Formosa.—Petroleum is known to occur in several localities, but has not been obtained in such quantity as to make it of industrial importance.

(65.) It will thus be seen that in addition to those countries at present furnishing the world's supplies of petroleum, there are many other prospective sources, some of which are of very considerable potential importance, and may assume high commercial value. In the countries now producing there are also many districts known to be oil-bearing which will be brought into development to meet the increasing requirements of the industry.

It is not possible until the test of the drill has been applied to form any estimate of the further aggregate area thus available, but it must be very large.

(66.) In respect of the quantity of oil which can be obtained from a given area, it will readily be understood that the varying character of the conditions preclude the framing of any estimate applicable to undeveloped territory.

It has been found by experiment that the oil bearing formation in parts of the United States oilfields would hold from one-tenth to one-eighth of its bulk of petroleum, but even if the contents were only one-tenth of 1 per cent., and the thickness of the stratum were 500ft., figures which are considered to be within the limits, the amount of petroleum would be 87,465,000 imperial gallons to the square mile. In this connection it should be pointed out that the production of small areas of the richest territory in Pennsylvania has been about 31,500,000 imperial gallons per square mile.

Some of the richest petroliferous strata of the Russian oilfields contain one-fifth of their bulk of petroleum, and on that assumption each square mile would yield for each 100ft. in depth or thickness of oil rock, 3,474,819,532 imperial gallons.

(67.) That there is ample scope for energy and the employment of capital in opening up fresh sources of supply if petroleum is to be largely and generally used as a source of power must be evident. Those who talk lightly of petroleum replacing coal cannot realise what is involved in such a change. Hitherto, exported petroleum products have been chiefly used by the pint as a source of light, or in small quantities for the lubrication of machinery; and to supply the markets of the world with a commodity which is to be burned by the ton, is another matter. The world's production of petroleum for 1891 was 5,746,139,573 imperial gallons. This is equivalent to 21,804,547 statute tons. For the same year the world's output of coal was 789,128,476 metric tons, or 776,664,473 statute tons. Weight for weight, the output of petroleum was therefore only 2·8074 per cent. of that of coal. Assuming that the present output of petroleum in the world were doubled, and that the whole of the surplus thus created were used as fuel, this would only be equivalent (taking into account the relative thermal efficiencies) to about 5 per cent. of the world's output of coal. I pass on now to transport.

Dr. Boverton Redwood.
28 April 1903.

III.—TRANSPORT.

(68.) With the general introduction of the system of transport in bulk in specially constructed tank steamers, the export of petroleum from the United States and Russia underwent a great change, and the business necessarily became concentrated in the hands of a comparatively few. The fleet of vessels employed in this work is a large one, and, as will be seen from the following list which has been compiled by my brother, Mr. Robert Redwood, a considerable proportion sail under the British flag. Many of these steamships are of large carrying capacity, and some of those most recently built take a cargo of no less than 10,000 tons of oil.

LIST OF PETROLEUM TANK STEAMERS.

BRITISH OWNED.

Name.	Gross Register. Tons.
"Alchymist"	382
"Appalachee," late "Duffield"	3,767
"Aral"	2,826
"Aras"	3,350
"Astrakhan	3,438
"Attaka"	310
"Aureole"	3,975
"Azov"	2,332
"Baku Standard"	3,708
"Balakani"	3,696
"Batoum"	4,064
"Beacon Light"	2,763
"Bloomfield"	4,455
"Broadmayne," late "Oka"	3,095
"Bullmouth"	4,018
"Bulysses"	6,069
"Cardium"	6,068
"Caucasian"	4,656
"Chesapeake"	4,557
"Chigwell"	1,824
"Circassian Prince"	2,243
"Clam"	3,552
"Conch"	3,555
"Cowrie"	4,893
"Cymbeline"	4,530
"Delaware"	3,688
"Elax"	4,015
"Euplectela"	3,918
"Floriana"	6,500
"Genesee," late "Darial"	2,767
"Georgian Prince"	3,245
"Gloriana"	6,060
"Haliotis"	1,659
"Henri Reith"	2,265
"Hotham Newton"	2,661
"Housatonic," late "Northern Light"	3,893
"Imperial," late "Minoco"	796
"James Brand"	3,907
"Khodoung"	1,457
"Kinsman"	4,534
"Kura"	2,372
"Lackawanna"	3,855
"Lucerna"	3,242
"Lucifer"	3,823
"Luciline"	3,765
"Lumen"	2,357
"Mexican Prince"	3,028
"Mexicano"	1,973
"Mira"	3,700
"Murex"	3,564
"Narragansett"	8,000
"Oilfield"	4,005
"Oranje Prince"	1,868
"Oriflamme"	3,764
"Osceola"	393
"Ottawa," late "Elbruz"	2,742
"Pectan" No. 2	7,300
"Petriana"	1,672
"Pennoil"	4,434
"Phosphor"	2,023
"Pinna"	6,288
"Potomac"	3,868

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Dr. Boverton Redwood.

28 April 1903.

Name.	Gross Register. Tons.
"Prudentia"	2,730
"Rion"	2,186
"Robert Dickinson"	2,100
"Rocklight"	3,225
"Russian Prince"	2,716
"Sabine Rickmers"	1,026
"Saint Helens"	4,007
"Said"	344
"Saxoleine"	3,757
"Silverlip"	7,600
"Snowflake"	2,710
"Spondilus," No. 2	7,300
"Strombus"	6,030
"Suram"	3,629
"Suwanee," late "Kasbek"	2,736
"Syriam"	1,427
"Tancarville"	2,336
"Telena"	4,778
"Terek"	3,710
"Texiana"	6,500
"Timsah"	349
"Tioga," late "Christine"	2,197
"Tonawanda," late "Lucigen"	3,416
"Trigonia"	1,667
"Trocas"	4,129
"Turbo"	4,134
"Tuscany"	4,006
"Tuscarora"	6,117
"Vedra"	4,057
"Volute"	4,006
"Weehawken"	2,784
FOREIGN OWNED.	
"Abas Dadacheff"	1,035
"Adschi Aga"	1,019
"Aga Manafoff"	1,108
"Aga Selim"	698
"Alekber Oseinoff"	2,000
"Alesgerje"	606
"Ali Dadascheff"	541
"Ali Ousejnoff"	599
"Alla Verdi"	994
"Amasie"	543
"American"	3,526
"Anna"	1,048
"Apscheron," late "Era"	1,851
"Ashot Erkat"	1,053
"Asia"	1,169
"Astych"	597
"Atland," late "Marquis Scicluna"	1,599
"Atlas"	1,942
"August Korff"	4,131
"Babalan"	536
"Bayonne"	3,294
"Besitung"	417
"Bremer Vulkan"	759
"Borjom"	2,874
"Brilliant"	3,162
"Burgermeister Petersen"	2,794
"Cadagua"	2,394
"Charlois"	2,744
"Chester"	2,834
"Chorosan"	546
"Cuidad de Reus"	1,899
"Czar Nicolai II."	2,104
"Dana"	207
"Daghestan"	2,774
"Deutschland"	3,796
"Diamant"	3,525
"Dordt"	191
"El Gallo"	632
"Elise Marie"	3,568
"Energie"	2,910
"Erivan"	2,424
"Etelka"	2,373
"Excelsior"	3,796
"Ezio," late "Titian"	1,249
"Gani Ousejnoff"	1,077
"Geestemunde"	2,750
"George Loomis"	691
"Grigor Arzrouni"	545
"Gut Heil"	2,552
"Halaban"	536
"Helios," late "Aco"	3,477
"Ignatief"	1,051
"Joannis Coutzis," late "Caucase"	1,666
"Jupiter"	1,435
"Kahn Usejnoff"	853

Name.	Gross Register. Tons.
"Kette"	58[illegible]
"La Campine"	2,542
"La Flandre"	1,979
"La Hasbaye," late "Œvelgonne"	2,539
"La Madeleine," late "Hafis"	2,116
"Le Coq"	3,399
"Le Lion"	2,593
"Le Progres"	449
"Lindesnaes"	375
"Looch"	1,446
"Ludwig Nobel," late "Petroles	967
"Makkavei"	1,651
"Mamed Aga"	536
"Mamedshakh"	552
"Manhattan"	3,300
"Mannheim"	3,507
"Margaretha"	2,115
"Martin"	583
"Maverick"	1,722
"Mechti"	789
"Minastan"	586
"Meteor"	4,151
"Mirza Aga"	792
"Misirje"	590
"Moskva"	577
"Ocean"	2,835
"Oural," late "Hans and Kurt"	2,422
"Ouady"	364
"Paraguay"	2,201
"Pasha Dadascheff"	1,054
"Paula"	2,675
"Phœbus"	6,200
"Pouschkin"	1,043
"Rasoul"	997
"Rossija"	3,952
"Rotterdam"	4,273
"Salahadji," late "Astral"	2,280
"Samarkand"	976
"Saruchan"	647
"Sevan"	473
"Sophie"	1,671
"Standard"	2,765
"Suleiman Ossinoff"	2,000
"Sultan van Langkat"	2,325
"Sviet"	1,827
"Tatjana"	1,594
"Tiflis"	2,783
"Useinia Manafoff"	1,041
"Valeria"	247
"Vardan Zoravor"	540
"Venture"	1,330
"Ville de Douai"	1,723
"Vorotan"	543
"Washington"	4,171
"Whittier"	1,100
"Willkommen"	3,136
"W. Lindberg"	1,046

(69.) Some special products are still carried in barrels of 41 imperial gallons capacity, and "cases," consisting of two tins (each holding 4 imperial gallons) in a wooden box.

13354. May I ask whether this list of steamers is a list of steamers wholly and entirely used for conveying oil in bulk?—They were built with a view of their being used in most cases solely for that purpose, but some of the steamers, notably those constructed for the Shell Transport and Trading Company, are so arranged that they can be employed, and are employed, in the carriage of ordinary merchandise.

IV.—STORAGE AND DISTRIBUTION.

(70.) The adoption of transport in bulk has also had the effect of concentrating the storage at points convenient for the discharge of vessels having a considerable draught of water. At the points specified in Table C, for the compilation of which I am also indebted to my brother storage installations of large capacity have been erected, and the tank steamers discharge through pipe-lines into the receiving tanks, the arrangements being such that the contents of a large vessel can be transferred in about 40 hours. Nearly all these stores belong to the companies engaged in the business, most of the previously existing public wharves at which petroleum products were formerly warehoused in barrels having disappeared as the outcome of the adoption of the bulk system. From the main storage installations the products are transferred to a very large extent by tank wagons and tank barges to distributing depôts on the

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railways, rivers, and canals, and a large proportion is from these conveyed to the doors of retailers by means of tank road wagons. Thus a large part of the petroleum finds it way from the wells to the consumers without being put into any special package, and this system results in marked economy. Table D shows the imports of various petroleum products into the United Kingdom for the year 1902:—

TABLE C.

LIST of the Principal PETROLEUM STORAGE INSTALLATIONS in the United Kingdom, with Capacities in Barrel Units of 41 Imperial Gallons.

LOCATION.	No. of Tanks.	Aggregate Capacity.
LONDON:		
London and Thames Haven Oil Wharves, Ltd., Thames Haven.	28	310,950
Roumanian Oil Trust, Ltd., Thames Haven.	4	50,180
General Oil Storage Co., Ltd., Thames Haven.	1	23,760
Caucasian Petroleum Export Co., Thames Haven.	2	About 50,000
Anglo-American Oil Co., Ltd., Purfleet.	28	359,670
Pure Oil Co., Purfleet - -	3	About 60,000
St. Leonard's Wharf Co., Bromley, E.	14	124,980
St. Leonard's Wharf Co., Battersea.	4	11,960
St. Leonard's Wharf Co., Greenwich.	2	9,400
Consolidated Petroleum Co., Ltd., New Beckton.	5	138,620
Consolidated Petroleum Co., Ltd., Deptford.	4	13,360
Consolidated Petroleum Co., Ltd., Fulham.	2	5,880
Silvertown Oil Storage, Minoco Wharf, Silvertown.	12	167,720
London and Thames Haven Oil Wharves, Ltd., Silvertown.	8	18,100
Anglo-American Oil Co., Ltd., Silvertown.	5	21,090
Anglo-American Oil Co., Ltd., Old Charlton.	2	About 10,000
London and Thames Haven Oil Wharves, Ltd., Bow, E.	6	47,140
Caucasian Petroleum Export Co., Bow, E.	2	About 9,000
London Oil Storage Co., Ltd., Dudgeon's Wharf, Millwall, E.	18	89,900
London Oil Storage Co., Ltd., Palmer's Wharf, Bethnal Green, E.	Underground tanks.	60,000
London Oil Storage Co., Ltd., Mellish's Wharf, Millwall, E.	Underground tanks used for turpentine and rape oil.	15,000
Anglo-American Oil Co., Ltd., Ailsa Wharf, Bromley, E.	2	About 21,000
Anglo-American Oil Co., Ltd., Hammersmith.	–	About 20,000
Wouldham Cement Co., Grays	1	41,200
Ragosine and Co., Ltd., Albion Wharf, Bow, E.	2	3,100
London, Brighton and South Coast Railway Co., Battersea.	1	16,150
Gas Light and Coke Co., Beckton Works.	5	89,100
Gas Light and Coke Co., Kensal Green.	3	54,100
Gas Light and Coke Co., Bromley.	2	40,000
Gas Light and Coke Co., Fulham.	1	14,320
Gas Light and Coke Co., Nine Elms.	2	32,900
West Ham Gas Co. -	2	5,840
Caucasian Petroleum Export Co., Hackney Wick.	1	About 8,000
LIVERPOOL AND BIRKENHEAD:		
Mersey Dock and Harbour Board, Herculaneum Dock.	5	87,200
Anglo-American Oil Co., Ltd., Birkenhead.	9	126,530
Liverpool Storage Co. - -	12 (9 case mate tanks.)	54,720
Corporation Gas Works - -	2	25,000
MANCHESTER:		
Consolidated Petroleum Co., Ltd., Eccles.	5	141,700
Liverpool Storage Co., Trafford Park.	6	66,000
Anglo-American Oil Co., Ltd., Trafford Park.	9	80,600
Corporation Gas Works, Trafford Park.	2	25,700
Pure Oil Co, Trafford Park -	2	50,340
General Oil Storage Co., Ltd., Trafford Park.	1	46,200
Caucasian Petroleum Export Co., Trafford Park.	2	About 50,000
AVONMOUTH:		
Anglo-American Oil Co., Ltd., Avonmouth Dock.	9	116,720
Western Petroleum Co., Avonmouth Dock.	2	40,900
HULL:		
Consolidated Petroleum Co., Ltd.	9 (5 boiler tanks.)	54,600
Anglo-American Oil Co., Ltd.	5	60,400
SOUTH SHIELDS:		
Anglo-American Oil Co., Ltd.	4	46,500
Consolidated Petroleum Co., Ltd.	5	22,700
SUNDERLAND:		
Anglo-American Oil Co., Ltd.	3	51,740
PLYMOUTH:		
Anglo-American Oil Co., Ltd.	3	41,800
Plymouth Gas Co. - - -	4	17,300
SOUTHAMPTON:		
James Barringer and Sons, Northam.	5	42,540
Gas Co. - - - - - -	3	About 8,500
CARDIFF:		
Western Petroleum Co., Penarth.	5	39,500
BARROW:		
Anglo-American Oil Co., Ltd.	8	111,000
Furness Railways - - -	2	16,500
BRIGHTON:		
Gas Co. - - - - - -	3	9,480
Anglo-American Oil Co., Ltd.	2	About 5,200
PORTSMOUTH:		
James Barringer and Sons -	2	1,200
Gas Co. - - - -	—	About 5,000
SWANSEA:		
Gas Co. - - - - - -	2	7,300
LOWESTOFT:		
Anglo-American Oil Co., Ltd.	1	8,600
IPSWICH:		
Anglo-American Oil Co., Ltd.	1	4,380
CHATHAM.		
Anglo-American Oil Co., Ltd.	1	3,200
MIDDLESBRO':		
Corporation Gas Works - -	1	12,800
DUBLIN:		
Anglo-American Oil Co., Ltd.	3	66,700
Alliance Gas Co. - - -	4	36,000
BELFAST:		
Anglo-American Oil Co., Ltd.	3	43,500
Consolidated Petroleum Co., Ltd.	3	61,170
Corporation Gas Works - -	3	37,800

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Dr. Boverton Redwood.

28 April 1903.

TABLE D.*

IMPORTS OF PETROLEUM (KEROSENE AND GAS OIL).

AMERICAN.

1900.

Port.	Barrel units of 41 Imperial gallons.			
	Standard White.	Water white.	Total.	Gas Oil.
London	795,690	206,810	1,002,500	164,340
Liverpool	274,580	71,870	346,450	86,130
Manchester	104,880	100	104,980	72,260
Avonmouth	316,270	20,100	336,370	42,150
Hull	232,980	26,000	258,980	—
South Shields	97,800	12,620	110,420	—
Sunderland	50,750	—	50,750	—
Cardiff	23,020	—	23,020	—
Plymouth	92,880	2,160	95,040	26,320
Southampton	22,010	—	22,010	—
Swansea	—	—	—	6,550
Dublin	164,750	5,290	170,040	—
Belfast	97,340	6,950	104,290	—
	2,272,950	351,900	2,624,850	397,750

1901.

Port.	Barrel units of 41 Imperial gallons.			
	Standard White.	Water white.	Total.	Gas Oil.
London	815,980	226,070	1,042,050	335,420
Liverpool	236,000	65,800	301,800	89,090
Manchester	70,010	—	70,010	69,230
Avonmouth	287,850	19,370	307,220	43,130
Hull	239,100	26,400	265,500	23,390
South Shields	73,370	9,460	82,830	—
Sunderland	86,860	—	86,860	—
Cardiff	40,870	—	40,870	
Plymouth	54,070	3,510	57,580	13,630
Southampton	33,570	890	34,460	
Barrow	47,980	—	47,980	
Swansea	—	—		3,460
Dublin	145,510	2,210	147,720	18,940
Belfast	52,030	6,930	58,960	—
Cork	3,480	—	3,480	
	2,186,680	360,640	2,547,320	696,290

The figures for the years 1900 and 1901 were supplied subsequently at the request of the Commission (Question 13553)

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TABLE D.*—*continued.*

IMPORTS OF PETROLEUM (KEROSENE AND GAS OIL)—*continued.*

AMERICAN—*continued.*

1902.

PORT.	Barrel units of 41 Imperial gallons.			
	Standard White.	Water white.	Total.	Gas Oil.
London	730,540	209,780	940,320	486,100
Liverpool	203,800	51,980	255,780	109,100
Manchester	62,810	1,000	63,810	49,440
Avonmouth	311,340	20,480	331,820	28,140
Hull	197,120	22,590	219,710	34,810
South Shields	41,620	6,940	48,560	—
Sunderland	78,940	—	78,940	—
Cardiff	15,330	—	15,330	—
Plymouth	83,240	3,030	86,270	5,570
Southampton	102,180	12,550	114,730	—
Barrow	107,110	8,820	115,930	—
Swansea	—	—	—	7,390
Dublin	161,000	13,320	174,320	9,640
Belfast	68,330	11,720	80,050	14,600
Total	2,163,360	362,210	2,525,570	744,790

RUSSIAN.

1900.

PORT.	Barrel units of 41 Imperial gallons.			
	Ordinary.	High test.	Total.	Solar Oil.
London	492,290	106,560	598,850	355,810
Liverpool	73,620	—	73,620	22,800
Manchester	306,380	77,420	383,800	57,230
Hull	32,510	—	32,510	—
South Shields	55,160	—	55,160	—
Cardiff	71,530	—	71,530	—
Barrow	17,000	—	17,000	—
Southampton	6,110	—	6,110	—
Dublin	11,250	—	11,250	40,520
Belfast	94,730	—	94,730	37,320
	1,160,580	183,980	1,344,560	513,680

* The figures for the years 1900 and 1901 were supplied subsequently at the request of the Commission (Question 13553).

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Dr. Boverton Redwood.

28 April 1903.

TABLE D.*—*continued.*

IMPORTS OF PETROLEUM (KEROSENE AND GAS OIL)—*continued.*

RUSSIAN—*continued.*

1901.

PORT.	Barrel units of 41 Imperial gallons.			
	Ordinary.	High test.	Total.	Solar Oil.
London	560,930	18,030	578,960	198,450
Liverpool	94,650	—	94,650	48,060
Manchester	208,740	13,440	222,180	121,330
Avonmouth	58,920	—	58,920	—
Hull	62,140	—	62,140	—
South Shields	66,430	—	66,430	—
Cardiff	52,270	—	52,270	—
Southampton	10,640	—	10,640	—
Dublin	—	—	—	18,950
Belfast	83,110	—	83,110	42,850
	1,197,830	31,470	1,229,300	429,640

1902.

PORT.	Barrel units of 41 Imperial gallons.			
	Ordinary.	High-test.	Total.	Solar Oil.
London	646,390	10,300	656,690	235,630
Liverpool	105,830	—	105,830	11,900
Manchester	235,150	18,380	253,530	70,270
Avonmouth	45,680	—	45,680	—
Hull	74,010	—	74 010	20,190
South Shields	89,000	—	89,000	—
Cardiff	50,210	—	50,210	—
Plymouth	—	—	—	24,640
Southampton	10,780	—	10,780	—
Middlesbro'	7,870	—	7,870	—
Dublin	57,880	—	57,880	—
Belfast	170,370	—	170,370	—
Total	1,493,170	28,680	1,521,850	362,630

* The figures for the years 1900 and 1901 were supplied subsequently at the request of the Commission (Question 13553).

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IMPORTS OF PETROLEUM SPIRIT.

AMERICAN.

1900.

In Barrels.

Description.	Ports.				
	London.	Liverpool.	Bristol.	Dublin.	Total.
Ordinary and deodorized - -	35,807	52,500	8,050	698	97,055
76° gasoline, motor car spirit, &c.	17,675	3,850	600	—	22,125
Benzine - - - - - -	2,750	6,100	700	—	9,550
Total - - -	56,232	62,450	9,350	698	128,730

In Cases.

Description.	Ports.			
	London.	Liverpool.	Bristol.	Total.
Gasoline - - - - - -	2,000	5,000	2,250	9,250

1901.

In Barrels.

Description.	Ports.			
	London.	Liverpool.	Bristol.	Total.
Ordinary and deodorized - -	41,082	28,948	8,444	78,474
76° gasoline, motor car spirit, &c.	21,300	6,700	2,300	30,300
Benzine - - - - - - -	2,395	5,200	800	8,395
	64,777	40,848	11,544	117,169
Grade unknown - - - - -	4,182	6,464	—	10,646
Total - - -	68,959	47,312	11,544	127,815

In Cases.

Description.	Ports.			
	London.	Liverpool.	Bristol.	Total.
Gasoline - - - - - -	6,500	5,100	3,000	14,600

The figures for 1900 and 1901 were supplied subsequently at the request of the Commission (Question 13553).

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Dr. Boverton Redwood.

28 April 1903.

IMPORTS OF PETROLEUM SPIRIT—*continued.*

AMERICAN—*continued.*

1902.

In Barrels.

Description.	Ports.			
	London.	Liverpool.	Bristol.	Total.
Ordinary and deodorised	27,841	35,218	5,192	68,251
76° gasoline, motor car spirit, &c.	29,099	11,500	3,550	44,149
Benzine	1,000	3,500	300	4,800
	57,940	50,218	9,042	117,200
Grade unknown	—	4,528	—	4,528
Total	57,940	54,746	9,042	121,728

In Cases.

Description.	Ports.			
	London.	Liverpool.	Bristol.	Total.
Gasoline	2,500	4,500	500	7,500

BORNEO.

Description.	Port	1901.	1902.
Ordinary	London.	Barrels. 23,890	Barrels. 81,193

IMPORTS OF PETROLEUM PRODUCTS INTO THE UNITED KINGDOM (WITH SOURCES OF SUPPLY), DURING THE YEAR 1900.

Description.	Ports.				
	United States.	Russia.	Roumania.	Borneo.	Total.
Petroleum Spirit :—					
Ordinary and deodorised	97,055 barrels	—	—	—	97,055 barrels
76° gasoline, motor car spirit, &c.	22,125 ,,	—	—	—	22,125 ,,
Gasoline	9,250 cases	—	—	—	9,250 cases
Benzine	9,550 barrels	—	—	—	9,550 barrels
Petroleum Oil :—					
Ordinary kerosene (lamp-oil)	2,272,950 ,,	1,160,580 barrels	24,140 barrels	—	3,457,670 ,,
Water-white or high-test oil	351,900 ,,	183,980 ,,	—	—	535,880 ,,
Gas oil	397,750 ,,	513,680 ,,	106,090 ,,	48,990 barrels	1,066,510 ,,

The "barrels" in the foregoing table are barrel-units of 41 Imperial-gallons. The "cases" contain 8 Imperial gallons. The figures for 1900 and 1901 were supplied subsequently at the request of the Commission (Question 13553).

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IMPORTS OF PETROLEUM PRODUCTS INTO THE UNITED KINGDOM, &c.—*continued.*

DURING THE YEAR 1901.

Description.	Ports.				
	United States.	Russia.	Roumania.	Borneo.	Total.
Petroleum Spirit :—					
Ordinary and deodorised	78,474 barrels	—	—	23,890 barrels	102,364 barrels
76° gasoline, motor car spirit, &c.	30,300 ,,	—	—	—	30,300 ,,
Gasoline	14,600 cases	—	—		14,600 cases
Benzine	8,395 barrels	—	—		8,395 barrels
Grade unknown	10,646 ,,	—	—	—	10,646 ,,
Petroleum Oil :—					
Ordinary kerosene (lamp-oil)	2,186,680 ,,	1,197,830 barrels	49,050 barrels	—	3,433,560 ,,
Water-white or high-test oil	360,640 ,,	31,470 ,,	—	—	392,110 ,,
Gas oil	596,290 ,,	429,640 ,,	33,260 ,,	—	1,059,190 ,,

The "barrels" in the foregoing table are barrel-units of 41 Imperial gallons. The "cases" contain 8 Imperial gallons.

DURING THE YEAR 1902.

Description.	Ports.				
	United States.	Russia.	Roumania.	Borneo.	Total.
Petroleum Spirit					
Ordinary and deodorised	68,251 barrels	—	—	81,193 barrels	149,444 barrels
76° gasoline, motor car spirit, &c.	44,149 ,,	—	—	—	44,149 ,,
Gasoline	7,500 cases	—	—	—	7,500 cases
Benzine	4,800 barrels	—	—	—	4,800 barrels
Grade unknown	4,528 ,,	—	—	—	4,528 ,,
Petroleum Oil :—					
Ordinary kerosene (lamp-oil)	2,189,840 ,,	1,493,170 barrels	67,420 barrels	—	3,750,430 ,,
Water-white or high-test oil	362,210 ,,	28,680 ,,	—	—	390,890 ,,
Gas oil	757,190 ,,	362,630 ,,	36,350 ,,	—	1,156,170 ,,

The "barrels" in the foregoing table are barrel-units of 41 Imperial-gallons. The "cases" contain 8 Imperial gallons.

†In addition to the products tabulated, there was in 1900 an import of 37,070 barrels of crude petroleum from Roumania and 44,730 barrels from Borneo. There is also a large annual import from the United States of lubricating oils of various descriptions in barrels, of which accurate statistics are not available. The import from the United States of these oils, including that which is brought in bulk, probably amounts to 500,000 or 600,000 barrels a year.

The shipments of lubricating oil in bulk from Russia expressed in barrel units of 41 Imperial gallons were as follows:—1900, 193,470; 1901, 178,150; 1902, 237,280.

Paraffin (scale and wax) is another petroleum product of which from 40,000 to 50,000 tons are imported annually from the United States and 3,000 to 4,000 tons from Burma.

Petroleum spirit is now chiefly employed as a source of power in internal-combustion engines on motor cars, etc.; it is also used as a source of light in "air-gas" machines, and for enriching coal-gas, as well as in "sponge-lamps" (lamps containing sponge or other absorbent material), and in admixture with coal-tar naphtha, or alone, in street "flare-lamps"; and for detergent purposes, in the process known as dry-cleaning. It is also to a considerable extent redistilled in this country, and converted into a number of products of different boiling-points, which are used for surgical purposes as a local anæsthetic (either alone or in admixture with sulphuric ether); for extracting resins, gums and fats; for "denaturing" alcohol; as a standard of light in photometric work; in motor-cars, motor-launches, and submarines; in dry-cleaning; in oil-cloth, paint and varnish making, etc. Petroleum spirit is also used by the following trades:—Helmet manufacturers, tennis-shoe manufacturers, india rubber manufacturers, waterproof-garment manufacturers, and glass silverers.

Petroleum oil is chiefly used in lamps as a source of light and heat (for cooking and warming); also in soap manufacture, laundry work, cleaning machinery, paint manufacture, etc.; and as a source of power in stationary internal combustion engines. A special description of high test burning oil (not included in the

†The figures for the years 1900 and 1901, and also the information contained in the paragraphs from † to § were supplied subsequently at the request of the Commission. (Question 13553).

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Dr. Boverton Redwood.

28 April 1903.

table) is burned in lighthouse lamps, steamship lamps, etc.

Gas oil is used as a source of illuminating gas in conjunction with water-gas. §

13355. (*Professor Dixon.*) How is the petrol spirit brought over now; is it brought over in metal vessels chiefly?—Partly in wooden casks and partly in metal vessels.

13356. What percentage is now brought over in the wooden casks, roughly?—For the year 1902 the total imports of suitable spirit for motor-cars—that is, the spirit known as petrol, amounted to 44,149 barrels; that is to say, there were 44,149 wooden casks, holding approximately 40 gallons each of such spirit, imported, and 7,500 cases, each containing 8 gallons, so that the proportion imported in cases was exceedingly small.

(*Chairman.*) Are those metal cases?

13357. (*Professor Dixon.*) Yes. Is that proportion increasing now, do you know?—No, I think it is about stationary, notwithstanding the fact that suggestions have been made that it would be desirable to substitute in many instances metal packages for the wooden barrels at present employed.

13358. Has the nature of the spirit—its volatility, and so on—altered since the rather larger use of motor engines?—Yes; quite recently it has been found impossible to meet the demand for spirit having a specific gravity of ·680, and large quantities of spirit are now being distributed for motor-car use having much larger specific gravities, up to as much as ·725.

13359. A specific gravity of ·68 would mean that it was practically a mixture of pentane and hexane. would it not?—That is so.

13360. You have analysed it, I suppose?—I have.

13361. No doubt your memory goes back 10 or 15 years to the spirit that was then imported from America, out of which, I dare say you remember, pentane is manufactured now?—Yes.

13362. Is this pretty much the same spirit as what was imported then, or is this rather heavier?—It is rather heavier.

13363. Owing to the larger consumption?—Yes, partly that, and it is partly due to the circumstance that the older oilfields are becoming exhausted, and the newer oilfields are not yielding a crude petroleum which gives quite the same character of petroleum spirit on distillation.

13364. That leads me to this point: going westward, have you found that the petroleum is generally of a higher specific gravity?—Unquestionably that is so.

13365. And in California is it the highest of all?—It is. On the other hand, there are some portions of the Wyoming oilfields which I visited two or three years ago where apparently a lighter oil can be obtained.

13366. If I remember rightly the oilfields of Wyoming have been only quite recently opened up?—There are some which have been opened up many years ago, but it is only recently that attention has been directed to the importance of developing the petroleum resources of Wyoming.

13367. But some new wells were sunk a few years ago?—Yes, quite recently.

13368. Which overflowed?—Yes, but still there are some wells in the Lander district in Wyoming which were drilled about 15 years ago, and which were fountains at the time—spouting wells.

13369. Which part of Wyoming?—In what is known as the Lander district, about 200 miles west of the town of Casper, which is the present terminus of the north-western railroad system.

13370. Does the quantity of benzene increase as you go westward, or is that peculiar to the Alaska fields?—I used the term benzine——

13371. Did you refer to real benzene?—Well, I was going to ask you whether you meant benzine or benzene.

13372. Benzene.—My answer on that point is that there is very little of the hydrocarbon benzene in any of this petroleum.

13373. There is some in the Russian petroleum?—There is, however, more in the oil that is found as you go further west.

13374. Yes, that is the point; and you have proved that it is really unquestionable benzene?—Yes.

13375. Did you refer to $C_6 H_6$ when you were speaking of Alaska?—No; I was then speaking of benzine, which is, of course, a description of petroleum spirit.

13376. Yes, I was rather surprised at your using the term?—I am much obliged to you for affording me the opportunity of giving that explanation.

13377. Would you tell us about those tar sands you have referred to? Have you been there at all?—No, I have not, although I have had occasion to make many reports on the district. I have had representatives out there, and I have gone into the question of the character of the oil indications with a practical driller of the name of Fraser, who has been employed by the Government to carry out some exploring work there. My information is second-hand in that sense, but it is nevertheless, I think, correct.

13378. It is a very considerable district in which you find this tar?—It is an enormous district.

13379. It is north of Saskatchewan, I think you said?—Yes.

13380. How far from the Rocky Mountains?—A part of it is not very far from the Rocky Mountains.

13381. I think you said it was disintegrated sandstone that it occurs in?—Yes.

13382. Is that above the carboniferous limestone?—Yes, just above.

13383. (*Professor Hull.*) Does not the sandstone rest directly on the carboniferous limestone?—Yes.

13384. And you believe that the oil has oozed up from the limestone and impregnated the sandstone?—That is what we believe.

13385. (*Professor Dixon.*) Then in the Rocky Mountains themselves, of course, there is carboniferous limestone?—Yes.

13386. Which has been, I suppose, broken through there?—No doubt.

13387. Is it possible that there can have been an escape of the lighter material?—I think it is very probable.

13388. You stated that there possibly had been an escape, but I wanted your own private opinion?—Until we have further evidence, which can only be got by drilling, I should be sorry to say whether there are effective deposits still existing or not, although the fact that there are places where natural gas escapes under pressure seems to point to the conclusion that there may be remaining effectively preserved deposits of petroleum.

13389. Pockets, as it were?—Yes.

(*Chairman.*) Is this in the neighbourhood of Winnipeg?

13390. (*Professor Dixon.*) A good deal to the north-west of Winnipeg; it is considerably to the north of the present railway?—Yes.

13391. Have you any views—no doubt you have—which you would care to give the Commission as to the formation of petroleum?—I think it must be admitted that no one theory will fit in with all conditions; that is to say, that any hypothesis as to the formation of petroleum which would be applicable to the older oilfields of the United States would not, in my opinion, be a satisfactory one as applied to the formation of such petroleum as one gets in some parts of California—a highly nitrogenous petroleum, which clearly could not have been formed in the same fashion as the comparatively non-nitrogenous petroleum of Pennsylvania.

13392. I do not know about the Californian petroleum. Can you give us a little information about that, as to where it occurs, and its nature?—There are a number of different and separate petroleum fields not very far from the coast, in the districts of Los Angeles and Santa Barbara and extending northwards over a very large area of country.

13393. Are they near the coast range?—Yes, some of them are actually on the coast range, or at the commencement of the coast range.

13394. I think you said north from Santa Barbara?—North and east.

13395. Going up to Monterey?—Yes.

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13396. Is there anything north of San Francisco?—Yes, there are some indications north of San Francisco.

13397. Is it all the same kind of petroleum?—No, it varies in character, although mainly it is an oil very different in nature from the oils which occur in the eastern and middle States.

13398. What is the nature of the nitrogenous body—is it known?—I am afraid I cannot say that it is known. I do not think that any attempt has been made to indicate exactly in what form the nitrogen occurs. Some of this oil is of a very peculiar description; I mean to say that its action when exposed, for instance, to sunlight is very similar to that of blood—that is to say, it decomposes—and Professor Peckham has reported that he has seen such petroleum full of maggots as the result of the decomposition that it has undergone, showing that it is a highly nitrogenous body, and I do not think action of that kind could occur with the presence simply of such nitrogenous bodies as those to which you alluded.

13399. You know, of course, Mendeleef's theory of the formation of petroleum?—Yes.

13400. Have you given any attention to that?—I am quite familiar with that.

13401. Would that apply to the Caucasian petroleum?—It is quite possible that some petroleum may have a strictly inorganic origin, such as Mendeleef has suggested. There is a good deal, of course, to be said in support of that theory. On the other hand, I have always considered that its best feature is that it is not possible to refute it.

13402. Of course, the point, I suppose, of the theory is that petroleum may be being manufactured at the present time?—That, no doubt, is the important aspect of it.

13403. But, so far as your personal knowledge and experience go, you have nothing to say in favour of it?—No; I can only say, as regards the question as to whether petroleum is in process of formation at the present time, that there are some oilfields which, after having been exhausted by pumping, gradually accumulate fresh supplies. That is particularly the case in regard to the oilfields of Enniskillen, in Canada, but I should not like to say that this is due to such an action as Mendeleef has suggested going on at great depths in the earth; it is far more likely to be due to the gradual escape of petroleum from a larger reservoir at some distance, filling up the cavities in the rock which have been drained by the action of the wells.

13404. That is to say, soaking through from another source?—Yes.

13405. (*Professor Hull.*) Do you not think that, in favour of the view that there is a continuous manufacture of petroleum by a natural process, there is the fact which you must admit, that the leakage in some of these districts, such as the Baku district, must have been going on for thousands and thousands of years; and is it possible to conceive that such a leakage as that should go on for such a lengthened period unless there was a continuous natural supply of the petroleum?—Well, first I would say that as regards natural leakage, a little oil makes a great show; and then, in connection with the question, I should like to remark that undoubtedly there is a definite fall in the horizon or level of the oil in the oil-bearing beds in the Baku field year by year.

13406. (*Chairman.*) Do you mean fall in the depth of it?—What I mean is that when the Baku field was first developed oil was obtained in great quantities by drilling to a depth of 200ft. or 300ft. Now it is necessary to drill to a depth of from 1,000ft. to 1,500ft. in the same localities to get the same supply; and if you look at the statistics of the depths of the wells you will find there has been a gradual increase in depth year by year, and you can in point of fact from the earlier years calculate what the depths would be for the succeeding years on that basis, the fall being something like, I think, 100ft. per year. I can go further, and say that there are some portions of the Balakhany field in Russia which, when I last visited the district, had almost ceased to yield oil—the wells were yielding mainly salt water, very little oil.

13407. (*Professor Hull.*) Is that by reason of the exhaustion caused by the pumping?—The only conclusion that I think one can draw is that there was a definite quantity of oil in the oil-bearing formation, and that in that particular district we had taken out all that nature had put there, and that she was not replenishing her stores.

13408. (*Professor Dixon.*) You put it in the same category as coal?—I think so.

Dr. Boverton Redwood.

28 April 1903.

13409. (*Chairman.*) What you have stated with regard to decomposition is new to me. I should like to ask whether you know if that is found in different parts of the world?—Do you mean that particular description of oil, my Lord?

13410. You spoke of a certain oil which, when exposed to the sun, showed not only decided signs of decomposition, but, as you describe it, became full of maggots?—Yes.

13411. Is that condition found in oil in other parts of the world besides the one you refer to?—Not to my knowledge. I have never seen it or heard of its occurrence anywhere else, but it is a phenomenon which has been observed in California.

13412. (*Professor Dixon.*) It must have some nutritive nitrogenous matter in it—some albuminoid, or something of that sort?—Yes. That is why I suggested there was something more there than the nitrogenous chemical constituents you indicated.

13413. I was only asking as to comparatively simple ones?—Yes.

13414. Except that the nitrogen is in what one may call an assimilable form we do not know further what it is?—I am afraid not.

13415. Then you give us some interesting information about large motor engines—I think you said of 6,000 h.p.—which had been made by or for the Russian Government for use in a destroyer?—Yes; the only information I have on that point is derived from a United States Consular report.

13416. Would you tell us what kind of engines they are; are they triple screws, or how do they get 6,000 h.p.?—I am afraid I cannot give you any detailed information upon that point.

13417. What is the largest naphtha engine in regard to horse-power which you know of that is working?—200 or 300 h.p.

13418. They are making them rather larger than that now; I have seen them?—Yes, but that is the largest I know of. They are building larger ones.

13419. I think you said that that large one was not for raising steam, but for combustion in a cylinder straight?—Yes, by internal combustion.

13420. Therefore 6,000 h.p. was rather remarkable?—Yes.

13421. They must have three sets of screws, and they would want about five cylinders on each shaft, I think?—I purposely gave the information exactly as it reached me, without vouching the accuracy of the statement made. I only stated that it was reported in a United States Consular document that such was the case.

13422. Then you also gave some interesting information about the use of light petroleum spirit as the expansive fluid in launches?—Yes.

13423. Is that a success, do you know?—Yes, it is used in that way, and so is alcohol used in a similar way. There is an engine known as the "Zephyr" launch engine, which is made to a considerable extent in America. Launches of that kind are carried by some of the largest American steam yachts, and Mr. Yarrow—the torpedo-boat builder—made some experiments on one of these engines, in which I gave him some help. We found that taking a small high-pressure engine, only 2 or 3 h.p., running it first with steam in the ordinary way, the boiler being heated by gas, we got for a certain consumption of gas a certain i.h.p., and then fitting a coil inside the same steam boiler and passing the spirit through it, and using the vapour of that spirit expansively, we got an equivalent i.h.p. by the consumption of half the quantity of gas, or if we burnt the same quantity of gas we got a largely increased h.p.

13424. That was petroleum spirit, was it?—Petroleum spirit—some of this ·680 spirit we have been previously talking about. A paper was read on the subject by Mr. Yarrow, at the Society of Arts, which will be found reported in the Journal of that Society, giving these results. But it does not follow, of course, that a system of that kind would be equally available on a large scale, and where you are working with a series of cylinders on a triple or quadruple basis and with effective con-

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Dr. Boverton Redwood.

28 April 1903.

densation, probably it would not be so. I think, of course, the great advantage of this exists only when the spirit is used in a high pressure engine without condensation—that is to say, without effective condensation—though the spirit is condensed and used over again. But I think it cannot be contended that a triple or quadruple expansion engine worked with the vapour of spirit in that fashion would show the same economy that we obtained on the small scale.

13425. It would want, of course, a very large condenser, would it not?—It would want a very large condenser.

13426. You could only use it on water?—I think you could only use it on water. Of course the merit of the system lies in the fact that the latent heat of the spirit is so exceedingly low.

13427. And the boiling point is low, too?—Yes.

13428. Of course ether has been tried, and did not succeed?—Yes. Alcohol is perhaps at the present time being used even more largely in that fashion than petroleum, in what is known as the Alco-vapour launch, which is also American. That is also carried in large steam yachts.

13429. Is that a success, do you think?—Yes. I would not carry one on my own yacht, because I do not like the idea of having anything so volatile and so readily inflammable on board a yacht where fire may occur.

13430. They use as near absolute alcohol, I suppose, as they can get it?—Yes.

13431. I should like to ask a few questions about the briquettes of solid petroleum to which you have referred?—Yes.

13432. What advantage is claimed over coal in the use of petroleum as a solid fuel such as that?—Higher thermal efficiency than in the case of steam coals. If you make a briquette similar to that of which I put in a specimen, containing 30 per cent. or 35 per cent. of petroleum, you would get a higher thermal efficiency out of it than out of a great many kinds of coal.

13433. Did you say lime or soda was used?—In that particular case the saponifying agent was lime. That would only contain 2 per cent. or 3 per cent. of lime.

13434. So that there would not be very much ash?—No.

13435. I suppose that the briquette gives rather a smoky flame, does it not?—No. It is quite possible to burn it in a furnace without contravening the regulations as to smoke emission.

(*Chairman.*) They are somewhat elastic, are they not?

13436. (*Professor Dixon.*) Yes; I think they depend upon the Inspector. What is the price?—I could not tell you what that cost.

13437. But the Commission may take it, I think, that, for instance, for use on board steamers or war-ships, the liquid character of petroleum is the great advantage?—Unquestionably it is.

13438. Which advantage is lost altogether by making it into briquettes?—Absolutely; and, of course, you do not get anything like as high thermal efficiency out of the petroleum used in that fashion.

13439. And yet you think there is a future for this petroleum briquette?—I think there is for certain purposes—for domestic purposes, for instance, in certain cases, where there is some inconvenience in getting supplies of liquid fuel. The very advantage that liquid fuel presents for certain purposes is a disadvantage in certain other cases.

13440. (*Chairman.*) Does the briquette deteriorate by keeping?—No, I should not expect to find that it does. I have not observed that in the case of other briquettes in which solidified petroleum is used.

13441. (*Professor Dixon.*) Could it compete with coal in Western Europe?—I think it could, looking to the fact that you would be able to work up a great deal of coal refuse which otherwise would be so much waste.

13442. You mean it is a means of burning coal dust?—Yes and inferior coal as well.

13443. I think you gave the flash point of the Russian kerosene—was it kerosene?—No, that was fuel oil I was referring to.

13444. You gave the flash point for that at 70° Centigrade?—Yes.

13445. That is 158° Fahr.?—Yes.

13446. What form of testing instrument was that taken in. Was it like the Abel test?—Yes, it is the German modification of the Abel test, which differs from the Abel test only in the fact that there is a mechanical arrangement for opening the test slide and applying the test flame—a clockwork arrangement. Instead of the operator having to pull the slide open by hand, which has to be done at a certain regulated rate, there is a little lever which releases a clockwork arrangement for opening the slide and applying the test flame.

13447. (*Chairman.*) Upon the question of flash point with regard to oil, is there any limit fixed by the Board of Trade, or by Lloyds?—Yes, there are two limits that have been fixed. I believe that a limit of 270° has been fixed for certain marine purposes.

13448. Is that the limit fixed by the Admiralty?—I believe it either is or has been until recently the Admiralty limit.

13449. Do you think that is higher than is necessary for safety?—I do. I do not think you can possibly secure safety by any flash point, if there is leakage, for instance of oil over the footplate in a stokehole; there they are sure to get it on fire whatever the flash point is; and I contend that if there is no leakage (and there ought not to be any) then 150° is high enough, because I do not think that tanks in which this oil is kept on board ship would ever acquire such a temperature as 150° Fahr.

13450. Under any conditions to which they would be exposed?—That is my opinion.

13451. Do you know what conditions there are or what specification there is on the battleships on which experiments with oil fuel are being made?—No, that is not within my knowledge, my Lord.

13452. But we may take it that in your opinion with proper storage 150° would give comparative safety?—Yes, I say so.

13453. You would not put it lower than that?—No, not in the light of my present knowledge and experience.

13454. But you think the main danger comes from the leakage rather than from the particular degree of flash point?—Yes.

13455. (*Professor Dixon.*) In the use on board ship of oil, is it equally applicable to be burnt in the case of a water-tube boiler as in the case of a cylindrical one?—Oh, I think so. It is entirely a question of the construction of the furnace. Of course, with all these various forms of "forsunka," as the Russians call them (that is to say, spray burners) you must have a very carefully constructed furnace in which the combustion is effected; you want to have fire-brick baffles and fire-brick linings in places in order to get an effective result. I have seen in fact, combustion chambers constructed for use and working with water-tube boilers that were giving very good results.

13456. In the locomotives that I have seen, the jet plays right on to a fire-brick plate and is scattered from that?—Yes.

13457. That is the usual plan?—Yes, I think that is for the locomotive.

13458. (*Chairman.*) But this is rather for the purpose of protecting the boiler-plate, is it not?—Yes.

13459. (*Professor Dixon.*) It is to reduce temperature jus at that point and to scatter the heat?—Yes.

13460. You say that you think there is no difficulty in burning it in a modern water-tube boiler?—I know there is no difficulty if you have a properly-constructed combustion chamber.

13461. There is one question I should like to ask with regard to the working of the Diesel engine. The temperature is reached by the pressure produced by the movement of the piston, is it not?—Yes, one of the strokes is a compression stroke.

13462. One of the strokes is a compression stroke, having taken in the charge of air and the petroleum?—Yes. As a matter of fact I think that what actually occurs in the cycle of working of the engine is this, that just at the instant before the maximum compression of the air is reached, the charge of petroleum, the necessary quantity for causing the formation of the explosive atmosphere, is injected into the space occupied by the compressed air.

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13463. By a separate pump?—Yes.

13464. Worked, of course, by the engine?—Yes.

13465. You gave us, I think, the temperature as being that of incandescence. You mean, I suppose, 600 deg. or 700 deg. Centigrade?—Well, naturally there must be some portion of the charge which is raised to the necessary temperature to bring about the combustion of the mixture.

13466. It would not be necessary, would it, that the actual metal surface should be so raised?—No, I do not mean to say that the metal is, but there must be some portion of the charge at the moment of combustion that is raised to the temperature. What I meant was, that as the result of the compression, the temperature of the gaseous mixture, or the temperature of the air and the petroleum which is injected into it, becomes raised to the point necessary to bring about the combustion of the mixture, that is to say, without the use of an electric spark such as is ordinarily employed in engines of that description.

13467. May I put it in this way: that if the temperature of that gas could be transferred to a solid, the solid would be incandescent?—That is it.

13468. But of course the solid is not?—No, that is so.

13469. (*Dr. Le Neve Foster.*) Might I ask a question with regard to the production of oil from oil shale in the United Kingdom. Do the figures which you give refer to the oil produced, or to the tons of shale produced?—The figures I have given are the numbers of tons of shale produced—mined—and in order to get at the quantity of oil, you can take it roughly that each ton yields about 30 gallons of oil. It varies, but that is, roughly speaking about the quantity of oil. Then multiplying the tonnage of shale by 30 will give you the total oil produced from shale in Scotland.

13470. How far is the deposit of tar sands in Canada from any railway?—I am afraid hundreds of miles.

13471. Therefore it is not likely to be utilised at present?—At present it is a very inaccessible region, and I do not see how anything can be done with those deposits until some railway is constructed in the district.

13472. With regard to the Alaska petroleum, you used the expression "a well-preserved district"?—Yes.

13473. In what sense were you using the words "well preserved"?—Because I find, on examining the petroleum, that it contains a large proportion of the more volatile constituents which would have escaped if the deposit had not been effectively covered by an impervious capping rock.

13474. Do you mean that there the impervious covering has been more impervious, if I may use the words, than usual?—Yes, more than it is in many places.

13475. Or less pervious than usual?—Less pervious than usual. We look at that as a favourable feature; it not only indicates that you can get an oil containing the more volatile constituents, but there is less likelihood of the original store of oil having been replaced by water and dissipated by the evaporation, and altered by oxidation, and so forth.

13476. Then you gave us some very interesting facts with regard to the Kimmeridge, shale of which large quantities exist. How is it that that shale is not being worked at the present time?—I think it is largely due to the discouragement that resulted from the circumstances that the late Sir George Eliot (I refer to the first Baronet) did a large amount of work and then gave up the project. I was a great deal consulted by Sir George Eliot some 15 or 18 years ago in regard to the utilisation of a portion of those Kimmeridge shale deposits underlying the Portisham estate. He sank a shaft and got out a quantiy of the shale and had it distilled at one of the Scottish oil refineries and made some effort to get the oil adopted for use in gas-making and for other purposes; but he did not meet with much encouragement. At that time there was no demand for a fuel oil. I think if there had been it would have turned the scale and made all the difference in the practical view he took of the case, but he became discouraged and gave it up. I think that has probably led to no others having attempted to make any use of these deposits. I may say that quite recently, that is to say, within the last few months, I have been consulted by some other people who contemplate taking steps very shortly to utilise these deposits with the object of manufacturing fuel oil; and the remarks that I made as to the probability that taking into account the profit derived from the sale of sulphate of ammonia, this shale could be mined and distilled and the oil sold for use as fuel in competition with coal, are very largely the outcome of a very recent inquiry which I have had to make for the people in question.

13477. (*Chairman.*) When you speak of "fuel oil" is that the same kind of oil that we use for making oil gas?—No, my Lord, it is not quite the same.

13478. The oil that is used for making gas is a shale oil, is it not?—It is a product which is intermediate, in regard to the boiling point and specific gravity, between the burning oil or lamp oil and the heavier description of the oil that is commonly used as fuel. A typical gas oil is an oil having a slightly higher specific gravity than ordinary kerosene or burning oil.

13479. But speaking of the oil which you describe as a fuel oil distilled from this Kimmeridge clay, would that oil, if differently treated, be suitable for making oil gas?—I should propose that if the Kimmeridge shale were distilled, a certain proportion of it, the lighter portion, should be made into what would be termed a gas oil, or oil for making gas, and the heavier portion reserved for use as a fuel oil.

13480. Because in the period you spoke of, 15 or 18 years ago, comparatively little oil was used for gas-making?—Yes, very little. It was only beginning to be known as a desirable agent to employ. It was tested, I may say, at the time by the Gas Light & Coke Co.

13481. (*Dr. Le Neve Foster.*) Then we may expect further developments before long in that district?—I think we may.

13482. With regard to the Red Sea—Gebel Zeit—if the indications there are so good, and if the results from actual bore-holes have been so good, what is the reason that nothing has been done within the last year or two?—I think that arose from the manner in which the work of development was carried out. In the first place the Egyptian Government offered a premium, as the outcome of certain statements which had been made to them, to anyone who could demonstrate that oil could be obtained in paying quantity in this locality: an engineer of the name of De Bay undertook to carry out certain work with the object of getting that premium. He drilled those wells to which I have referred in the evidence I have already given, and he claimed the premium. A Commission was sent out from Cairo to investigate the matter and to determine whether he was entitled to the reward, and they found that there was oil at the time of their visit being produced in paying quantities. The work was then entrusted to Dr. Tweddle, and the result not being commensurate with the expenditure the project was abandoned.

13483. Turning to another matter, has it not been proposed to use peat and petroleum and to make them into briquettes in some way?—Yes, that has been suggested.

13484. Is there anything in that?—Peat is a material that can be employed in the same way as coal as an ingredient with petroleum in a briquette of the sort that I have already referred to.

13485. (*Sir George Armytage.*) More or less in the place of the straw, I suppose?—Yes.

13486. (*Dr. Le Neve Foster.*) Is that likely to succeed for briquette making?—Peat is a difficult thing to handle. It occurs generally in places where the climate is not such as admits of the drying of the material without the employment of some artificial method of doing it. Moreover, you cannot dry peat effectively and cheaply unless you mash it up first, because its structure is such that it holds the water most obstinately unless it is all mashed up. Therefore the handling of peat to bring it into a condition in which it would form a satisfactory ingredient in a briquette is necessarily expensive, and where all that has to be done in a climate like that of Ireland, where it is nearly always raining, the drying is a costly thing.

13487. (*Chairman.*) Does it possess any value after it is torn to pieces, except as a carrier?—Oh yes. There is a manufacture at the present time in Norway and Sweden of peat fuel; they make a very satisfactory dense form of fuel by carbonising the peat in closed chambers so that the escape of the volatile matters is to a very great extent prevented. They get the oil products of the peat distillation retained to a large extent in the finished material.

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Dr. Boverton Redwood.

28 April 1903.

13488. (*Dr. Le Neve Foster.*) Is there anything to be hoped from processes for the solidification of petroleum?—There are the cases in which a solidified petroleum, or a briquette containing so-called solidified petroleum, might, I think, be advantageously employed; but for most purposes it appears to me that you do away with the great advantages that the liquid fuel presents over such a solid fuel as coal, for instance, by solidifying it. If you simply look at it from the point of view of carriage, as some do, then it necessarily is a costly thing to solidify the petroleum and to reconvert it into the liquid form before using it.

13489. But supposing you solidify it and use it in the solid form, is there any great advantage?—There are cases in which, for instance, for domestic use, the liquid fuel could not advantageously be employed.

13490. But not for use on steamers?—I cannot see any advantage in it in a case of that kind. It seems to me that you are destroying those features, upon which the superiority of the liquid fuel largely depends, by converting it into a solid.

13491. But are you not gaining something in safety?—I think not for industrial purposes; for domestic purposes, yes.

13492. (*Chairman.*) Do you gain anything in power; would it produce more?—No, less—you lose in power.

13493. (*Professor Dixon.*) Have any experiments been made with regard to the flash points of these solidified petroleums?—Yes, I have made a very large number of experiments, and others have done so, no doubt.

13494. Are they safer?—Yes, of course the effect of the incorporation of saponaceous material with the oil is to raise the flash point; it makes the oil safer; but if you have, for instance, a large quantity of briquettes made from an oil with a flash point of 73 degrees—the ordinary burning oil, for instance—and have those stored for a sufficient length of time in a close warehouse you would certainly find, as I proved experimentally, that in the course of time the atmosphere of that warehouse on a hot summer day might be combustible or explosive. Therefore it comes to this, that in order to safely carry out a system of manufacture of briquettes for ordinary consumption you must have an oil of a fairly high flash point.

13495. (*Dr. Le Neve Foster.*) Do you think there is any likelihood of petroleum supplanting coal in the Navy?—I think that the likeliest form in which petroleum could be employed, or will be employed for the purpose, is in the way that I have indicated, namely as a source of power for all the small engines that form part of the equipment of a modern man-of-war, when it would be used as an agent in an internal combustion engine.

13496. But not for driving the screw?—I do not see where we are going to get adequate supplies. As I have already pointed out, if you double the existing output of petroleum in the world it would only be an equivalent of about 5 per cent. of the present coal consumption.

13497. (*Chairman.*) That is, coal consumption for all purposes?—Coal consumption for all purposes, I am aware; but the proportion that is used for steam-raising purposes represents a large percentage. I have not gone into the question of the figures as to what proportion of the coal is used for steam raising, but I assume it must be a very large proportion; and I do not think that the output of petroleum would represent a very large percentage of the out-put of coal for that purpose, even taking into account the relative thermal efficiencies. Then to anything like double the present output of petroleum would mean an enormous expenditure of capital and would take a great deal of time. This petroleum industry has taken many years to build up apart from the fact that it has cost an enormous amount of money. At the present time the Americans cannot obtain all the crude oil that they want for the purpose of fulfilling their contracts. There is to some extent a scarcity of petroleum in America; there is a difficulty in getting from America sufficient petroleum spirit to satisfy the demands of those who are using it now in unexpected quantities for road vehicles; and a great deal of Russian oil is being distributed at the present time for gas-making and other purposes, simply because there is not enough American oil available. It is clear, therefore, of course, that no considerable amount of the present output of petroleum could be diverted into the comparatively new channel of use as fuel.

13498. (*Dr. Le Neve Foster.*) Has oil fuel been found to be smokeless in the burning of it in the Navy?—I am afraid it has not in the Navy. I think the combustion has been badly arranged, and badly carried out, and there have been serious complaints of the difficulty of getting, not merely smokeless combustion, but anything approaching to it.

13499. (*Chairman.*) Have you been on an oil-fired steamer where there was absolute freedom from smoke?—Yes, on the Caspian sea several times.

13500. Then, in your view, it is rather a question of the construction of the furnace than of the material?—There is no doubt about it.

13501. (*Mr Brace.*) But with the furnaces as they are at present arranged, smokeless steam coal has been quite as smokeless, or more so than oil, has it not?—Oh yes. I think you may say that the worst coal, the coal for instance that is used on some of the Clyde steamers, which is most objectionable in regard to the quantity of smoke given off, is very much better in that respect than oil as the oil has been burnt in some of the Navy experiments.

13502. (*Dr. Le Neve Foster.*) Has petroleum spirit been brought from Baku here?—Which description of petroleum?

13503. For motors?—No, not petroleum spirit. It is in contemplation to bring it, but it has not been brought yet, and I believe the reason why it has not been brought is because there have been no arrangements available for its transit.

13504. But if there were a pipe line from Baku to Batoum, and refineries in Batoum, we should be getting it?—No doubt: although it must be borne in mind that the Russian oil does not contain a large proportion of the more volatile hydro-carbons: it only yields 2 per cent. or 3 per cent.

13505. (*Professor Dixon.*) What is done with it?—It is either used as a fuel in the refineries or in some instances is burnt to waste—they run it out into an open space of ground and burn it away.

13506. (*Dr. Le Neve Foster.*) Have you paid any attention to natural gas?—I have paid a good deal of attention to it, in Russia for instance, and in America, but if you refer to Heathfield——

13507. That is what I was thinking of; I mean with regard to the question of supplies in this country?—I think it is very difficult to form any opinion at present as to whether that is not merely a curiosity rather than anything of practical importance.

13508. (*Chairman.*) It is still being used, is it not?—Certainly.

13509. And several stations are lighted with it, are they not?—Yes, and it seems as if the quantity were considerable.

13510. (*Dr. Le Neve Foster.*) Is there much being used in Russia?—To some extent it is being used as fuel. When I was there some years ago they were using it for lime burning in the neighbourhood of the Fire Temple at Surakhany.

13511. You mean near Baku?—Yes, but of course it is very much more largely used in America.

13512. Is there any case in Russia where gas is being piped to any district?—I do not know of any.

13513. Might it not very well be piped, considering the very large quantities of supply there are there?—Yes, I think it might.

13514. (*Mr. J. S. Dixon.*) In your evidence you mentioned making alcohol fuel from grain?—Yes.

13515. Is that likely to become a substitute for coal in any degree in the future?—I see no reason why we should not make alcohol in this country and use it effectively as a source of power just as is being done at the present time in Germany and France. At the present time the German Government is encouraging the cultivation of the potato for the purpose of making alcohol from it. Alcohol is being used very largely in internal combustion engines, and as a source of light.

13516. My question has reference to the question of whether the use of that would be a practical substitute for any quantity of coal in the immediate future?—I think it might, but at the present moment there is no encouragement to inventors to turn their attention to this subject, or for anyone to take up the cultivation of a source of alcohol on a large scale, because of the duty.

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13517. I think I saw some suggestion some time ago that alcoholic fuel should be used in the Royal Navy, so as to do absolutely without smoke. That would have a material bearing, if there is anything in it, upon the question of smokelessness, and the exhaustion of smokeless coal?—I do not think it would be reasonable to anticipate that if the whole of this country were devoted to the cultivation of a vegetable suitable for the production of alcohol, it would replace any large amount of smokeless coal.

13518. That is the difficulty. Generally speaking, the information we wish is, as to how far petroleum can be used as a substitute for coal, so as to preserve our coal supply. I take it from your evidence, you do not think that it can to any considerable extent?—For steam raising purposes I do not think it can. But I think that to a very large extent coal can be saved by much more extensively employing internal combustion engines with petroleum.

13519. (*Mr. Briggs.*) Or even coal gas?—Or even coal gas.

13520. Of course that would make a great saving?—That would make a great saving, but at present we are using our coal on the most wasteful system; we are getting about 12 per cent. out of it.

13521. (*Mr. J. S. Dixon.*) Do you think that the use of the petroleum in internal combustion engines for the purpose of creating power would cause a direct saving of coal?—Yes, I say so distinctly.

13522. (*Chairman.*) You mention the figure of 12 per cent. I think you told us in your evidence that as regards oil (used I presume in an engine such as you describe) you might get more than double that?—Yes, many of these engines give more than double, but they do not all of them do so.

13523. Does it mean that if the coal itself were turned into gas you would get more than double?—I think you would, certainly.

13524. (*Mr. Briggs.*) I do not know whether you have referred to the blast furnace oil in Scotland?—No, I have not referred to that.

13525. That is as a fuel, because I believe that has been used on the Clyde?—Oh yes.

13526. It once came very near consummation, at any rate. I suppose it is a matter of price with regard to that?—Yes.

13527. There is a largish supply?—Yes, a largish supply, although if there was any considerable demand it would not go very far.

13528. Then there is another matter you mention with regard to the American petroleum producing much more richly the light constituents than petroleum?—Yes.

13529. When you speak of American does it mean North American strictly or Texas, or what?—It means especially the petroleum which has been got in the older oil fields of the United States—what they call the Appalachian oil-fields. But I may say that there are other places in the world where crude oil containing even a larger proportion of the more volatile constituents is found, as, for instance, in Sumatra.

13530. Yes, I had heard that was so?—Sumatra petroleum spirit is being brought into this country at the present time, and is being used to some extent in motor carriages.

13531. Is there hope of more of that being available?—I think there is a very large supply of that available, but of course it has to be brought a great distance. The cost of carriage from Sumatra to this country is far higher than the cost of carriage from New York to this country.

13532. (*Chairman.*) Is that brought in tanks?—It is brought in tanks by the Shell Transport and Trading Company.

13533. (*Mr. Briggs.*) They might compete with the Americans, no doubt, but they will have difficulty in doing so, I presume?—Yes.

13534. There is hope, at any rate, of an additional supply to take the place of the shortage of the American supply, is there not?—I think that certainly in Sumatra there is a very large amount of petroleum available for that purpose.

13535. And of excellent quality for motors and for power producers, I suppose?—Some people complain that it does not give quite as good results as the American spirit, and I think there may be some justification for that, but at any rate it is available for the purpose.

Dr. Boverton Redwood.

28 April 1903.

13536. (*Mr. Teall.*) I think there is some evidence that oil shales decrease in value with depth?—That is so.

13537. Is that so in many districts you are familiar with?—I think it is the usual experience, but I cannot explain it.

13538. Are you thinking of any particular areas where that has been established?—I have heard of its being observed in the Australian shale fields as well as in Scotland.

13539. That is apparently a general law?—I think it appears to be so, but I cannot understand it, and I cannot account for it.

13540. (*Mr. Bell.*) You spoke about a pipe line being in the course of construction from Baku to Batoum?—Yes.

13541. For what purpose? I do not quite gather?—That is for the transport of kerosene, burning oil, refined oil.

13542. How do the different oils from different countries compare in commercial value in this country?—Russian oil always commands rather a lower price than American oil. Roumanian oil is about intermediate between the two.

13543. The price of oil to-day is about how much would you say—that is, wholesale price?—Well, I am afraid I have not noticed a quotation quite recently I suppose it would be about 5d. per gallon for an ordinary oil, or something thereabouts.

13544. (*Chairman.*) 4d. to 7d.?—Yes.

13545. (*Mr. Bell.*) But for power-raising purposes that would not represent the price for large quantities, would it?—Oh no.

13546. What may we call the price for that? Is it within your province to tell us that?—I should think that contracts judiciously made for Russian oil would probably be on the basis of about 3d., or perhaps even less.

13547. That, of course, is a very much lower price than used to obtain a few years ago?—Yes.

13548. When large amounts of capital were invested in oil-bearing districts?—Yes. It is not only, of course, due to change in respect of the production, but it is also largely due to the introduction of the bulk system of transportation, which admits of the whole industry being more economically conducted.

13549. Of course if anyone is embarking in enterprises of this character, I suppose it is generally admitted that they embark in something of a very much more speculative character than even embarking in a coal mine, would you say?—I think it is more difficult to apply any test to an undeveloped oil territory than to an undeveloped coal-field with a view of forming an opinion as to the probable value.

13550. Yes, that is what I thought, and I was wondering whether, at the present price of petroleum, for example, there would be much inducement to capitalists to embark in boring for oil in any part of the world?—I think the financial results obtained by the Standard Oil Company, for instance, or by the Burmah Oil Company, are quite sufficient to indicate that if the business is judiciously managed—effectively managed—it is a very profitable one.

13551. Do you think the Standard Oil Company is a fair representative instance of success in oil industries?—I think as regards recent years it is; I do not think they have had any exceptional advantages in recent years; they had originally, no doubt, in building up the business, but I do not think they have recently, and certainly that cannot apply in the case of the Burmah Oil Company.

13552. I suppose the value of oil will always be regulated to some extent by the price of coal in a country like this?—Yes if you look at it from the fuel point of view, no doubt that must be so.

13553. Could you obtain for us, or give us, any figures giving any estimate of the different purposes and the quantities in which the oil is used?—Yes, I think I can prepare a statement showing that, but I may say off hand that from the fuel point of view such a statement would indicate that there had been practically little or no use of petroleum in this country.

See page 205.

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Dr. Boverton Redwood.
28 April 1903.

13554. Would it be possible, do you think, to give statistics of the importation extending over two or three years; you gave us the importation for one year only?—Yes, I have the figures; I have not them here, but I have them at my office, and there would be no difficulty about my giving you the figures for the last three years.

13555. (*Chairman.*) I was going to ask you a question upon that. It would be interesting to know whether the figures which you have given us show any actual increase on the previous figures?—Yes, I will prepare corresponding figures for previous years; but I may say that the figures will show a steady increase in the consumption of petroleum, roughly, I suppose, of 10 per cent. to 15 per cent. per annum.

13556. For all purposes?—Yes. Of course the consumption of petroleum spirit for motor cars would exhibit an enormous increase—I suppose far more than double within recent months.

12557. (*Mr. Brace.*) Is there any reliable estimate as to the quantity of oil to be found in any given field? You have somewhat covered that question, but not fully I think?—I am afraid that it is not possible for me to add anything to what I have already said on that point. I have given the number of imperial gallons which could be obtained under certain assumed conditions in the oil-fields of America and Russia, and I have indicated that in my opinion it is scarcely possible to adopt any satisfactory basis of estimate in respect of undeveloped territory, because the conditions vary so greatly, and cannot of course be foretold till the test of the drill has been applied.

13558. I suppose an oil well may give out at any moment?—In exceptional cases it may give out without warning, so to speak, but as a rule there is a gradual decline in production and usually any well will continue to yield oil in paying quantity for at least five years, and sometimes for as long as 15 or even 20 years.

13559. Then your opinion from your evidence practically amounts to this, that there is but little hope of oil superseding coal?—I am afraid I must come to that conclusion. I think there will be certain selected applications of liquid fuel where the advantages of employing such a fuel are specially obvious, but for anything like general employment I cannot see where we are to look for adequate supplies.

13560. What is the difference in the mechanical appliances used upon the Caspian and those used in the ordinary vessel that you say was using oil as a fuel, and which gave such unsatisfactory results?—I think it is a question of the construction of the combustion chamber The arrangements for the burning of the oil on the steamers plying on the Caspian Sea are such as to afford opportunity for thoroughly satisfactory combustion of the hydro-carbons, whereas in the attempts that have been made to carry out the combustion of liquid fuel on our ships of war in this country, as far as I can judge from the results, they have not adopted means which admitted of satisfactory combustion. It is mainly a question of the arrangement of the furnace, the provision of a necessary supply of air, which, however, of course must be admitted in such fashion as not to bring about too much cooling.

13561. Of course, holding the opinion that you do not see where a sufficient supply of oil could be secured to take the place of coal, you would hardly recommend that there should be an alteration of the machinery so as to use oil instead of coal?—I do not think you could recommend that; I do not think it would be justifiable at the present time.

13562. I agree. So that unless oil can be used very largely with the present appliances, it would hardly pay to make a change?—Well, the change, of course, would have to proceed *pari passu* with the increase in supplies. The change is not a difficult one; it is not a costly one, and it does not occupy much time. A furnace can be adapted to burn liquid fuel, provided you know how to do it, in a comparatively short time; really you can have all the appliances ready in a few hours and at the expense of a few pounds. That, of course, as I say, would have to be done concurrently with the increase in available supplies.

13563. Of course the interesting point to the Commission—at least to me—is that you do not think oil can supersede coal?—I do not think it can to any large extent. I think, as I say, that there will be certain cases in which, as, for instance, in the employment of it in internal combustion engines, it will indirectly effect considerable saving of coal; but to employ to any large extent petroleum as a substitute for coal in steam raising is, in my opinion, quite out of the question.

13564. (*Chairman.*) It is practically the only material which can be used for spirit motors at present?—That is in internal combustion engines?

13565. Yes.—Yes; that is with the exception of alcohol.

13566. I mean all motor cars driven by petroleum could not use anything else in that form, could they?—Alcohol is, of course, being used; the French Government are encouraging the use of alcohol, or a mixture of alcohol and benzol, that is the benzene which Professor Dixon referred to earlier.

13567. By the way, I wanted to ask you a question with regard to that. You spoke about alcohol before, and, as you say, the French Government have been encouraging its use. How does it compare with the cost of coal from the point of view of efficiency, as you put it?—They say in France that they can sell this alcohol at a lower price than the petroleum, and the petroleum is being sold at such a price as apparently to compete with coal.

13568. Does that mean a price per gallon or a price per unit of efficiency?—That is on the basis of efficiency

13569. (*Professor Dixon.*) You put alcohol at about half the efficiency, do you not?—About half.

13570. (*Sir George Armytage.*) Could you give us roughly any comparison of the value of coal, and gas, and petroleum as regards efficiency?—Roughly speaking, if the petroleum and coal are satisfactorily burnt, and the coal is of fair average quality steam coal, the petroleum has nearly, but not quite, double the efficiency of the coal.

13571. That is to say, coal would work out at half the price as compared with petroleum?—Yes.

13572. How does that compare now with gas, taking a petroleum engine as against a gas engine of the same power?—I think the gas would be about on a par with the petroleum employed in an internal combustion engine.

13573. That is, if petroleum be as cheap as gas?—Yes

13574. Speaking about the pipe which is being laid from Baku to the Black Sea—I think you said it was not finished?—It should have been completed many months ago.

13575. Have you any idea of the comparative cost of carrying the petroleum by a pipe and by tanks as it is now carried?—It is very much lower by a pipe, taking into account the capital expenditure on the pipe, the cost of maintenance and the cost of working.

13576. Taking everything into account?—It is very much lower, but I cannot give you the actual figures.

13577. (*Chairman.*) It has to be pumped through the pipe, has it not?—Yes.

13578. (*Sir George Armytage.*) Forced on at intervals, I suppose?—Yes, that is the system adopted. Even where there is a fall in the pipe so that the oil would flow by gravitation, it is cheaper to use pumps, because you increase the capacity of the line.

13579. Can you give us any idea taking the average cost of coal, of the difference between the cost of coal and the cost of those briquettes of which you have told us; I mean with regard to their heating value, for producing the same heat?—I cannot give any actual figures; I can only say that a briquette containing about 25 per cent. of petroleum is supposed to give more heat than a good average steam coal.

13580. The same weight?—Weight for weight.

13581. But that would include the admixture of the coal dust, would it not?—Yes, that includes the whole, certainly.

13582. (*Mr. Bell.*) That would depend very much upon the quality of the coal dust, would it not?—It does depend upon the quality of the coal dust, certainly.

13583. I suppose people get an idea that if they can convert even rubbish into a briquette they can get the same power out of it?—Sewage sludge has been proposed for use in making petroleum briquettes, and it can be employed.

13584. (*Chairman.*) You spoke I thought rather gravely, and you said that a limitation of the flash point would very much limit the supply?—Yes, I feel that very strongly, my Lord.

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13585. I am afraid I did not quite gather what was in your mind as to how it would operate. Do you mean that a limitation of the flash point would exclude a large portion of oil which otherwise would be available?—It means this, that with most descriptions of crude petroleum in order to manufacture a fuel oil having a flash point of say 200° or 250° Fahr., one would have to separate by distillation a much larger proportion of the oil than would be necessary in the event of the standard of flash being fixed say at 150°. The petroleum consists of a mixture of a great many hydro-carbons of varying volatilities, and the flash point is raised in the process of manufacture by continuing the distillation and removing successively one fraction after another, the boiling points and flash points gradually increasing in that process until the desired flash point of the material is reached. Obviously, the higher the flash point required the smaller the amount of product you can get. Consequently, as I say, the effect of fixing a high flash point is to reduce the quantity available for the purpose, and if that point is put very high it would bring the quantity down to something exceedingly small. It is exactly the same argument as applies in the case of the flash point of kerosene. We know that if the flash point of kerosene were raised from the present legal standard to 100°, as has been proposed, there would be a correspondingly smaller quantity of the commercial product of kerosene obtainable from the crude oil.

13586. Then the process of manufacture does not pay in the bye-products or the separation of the more volatile portions?—The part that would be separated in raising the flash point say from 160° to 300° would be a product that is not well adapted for any particular purpose, and therefore, although it is not actually lost still it would have to be sold at a lower price.

13587. It is not a higher quality, it is not a higher value, at any rate?—No, of course if it had a higher value it would be an advantage to separate it.

13588. Quite so. Therefore the limitation might take place in one or two ways, first, the exclusion of the material owing to the cost of the process of raising the flash point, and therefore raising the price, I suppose?—Yes.

13589. And secondly, excluding oil which, except where manufactured, would have a lower flash point than would be permitted?—That is so.

13590. You will be good enough to give us those figures which you have been asked for with regard to past years?—I will.

13591. Just one general question upon that. You spoke about the increase, and you said that the figures would probably show an increase of ten per cent. per annum, I think?—Yes, I think it is about 10 to 15 per. cent. all round.

13592. Is it too large a question to ask you to look to the future and say whether that will continue?—I think there is every reason to believe that it will continue.

13593. Further districts will be found?—I think so. Our past experience I think teaches us that that will be the case.

13594. That as fields are exhausted others in greater quantity are discovered?—I think so.

13595. You look upon it, therefore, as a growing industry?—Undoubtedly.

13596. (*Mr. Bell.*) Will that depend more upon the supply, or upon the demand, do you consider?—I think the primary cause, of course, is the increasing consumption—the increasing demand.

13597. (*Chairman.*) That is for special purposes?—For special purposes.

13598. It will grow, no doubt; it began with the lamps?—Yes, and then of course, the lubricating oil business has increased to an enormous extent; mineral lubricants have been found for many purposes to be greatly superior to animal and vegetable oils, and have largely replaced them.

13599. Is it capable of being used for soap purposes, or will it not saponify?—It will not saponify, but a very large quantity of petroleum is at the present time being introduced into soap.

13600. But it is being put in bodily?—Yes, it is being dissolved; it is taken up and held by the soap in an exceedingly effective fashion. It is not a very easy thing, even by chemical analysis, to get out all that you know is in. There is one description of soap which has been the subject of several law suits within the past couple of months which contains a certain amount of petroleum spirit. Either petroleum spirit or petroleum oil in soap is found to have an excellent detergent effect, which greatly facilitates the operation of washing fabrics and assists in the removal of dirt. *Dr. Boverton Redwood.* 28 April 1903.

13601. (*Mr. Bell.*) You could not make a rough guess off hand as to the proportion of the total imports of petroleum that are used for raising steam, could you?—If you take simply the use of petroleum as a substitute for coal in steam raising, it is very, very small.

13602. When you speak of the demand growing for special purposes, you hardly include steam raising purposes in that, I take it?—I think that, while the steam engine is employed, there are certain purposes in respect of which liquid fuel might very advantageously replace coal, even at more than double the cost of coal; for instance, in electric power stations, where there frequently is a sudden demand for current, perhaps occurring at an unexpected time of the day in consequence of a fog, the use of liquid fuel presents enormous advantages. I know that in conversations which I have had with men in charge of electric power stations in great cities, I have been told that very frequently they clean their furnaces and remove the clinker from their bars in fear lest suddenly while the fire is low and everything unpropitious, a fog should come on, when everybody would switch on their electric light—and the suppliers of electric light must in some way find power. Of course, obviously, in a case of that kind it is an enormous advantage to be able to turn on at once any required amount of heat in the shape of liquid fuel; you have it absolutely under control; you can get up steam at very short notice; and in the case of solid fuel, perhaps by the time that, after great exertion, they have got their furnaces actively going again, the fog suddenly clears, and they have their furnaces full of fuel, and they do not know what to do with the steam; whereas the liquid fuel can be shut off and the loss prevented. So that I think for certain purposes of that kind petroleum would be specially valuable.

13603. (*Chairman.*) That would be still more easily accomplished, would it not, with the gas engine?—Undoubtedly, my Lord. I prefaced my remark by saying while we are employing the steam engine as a source of power.

13604. (*Dr. Le Neve Foster.*) But is it not easier to get your petroleum engine to work for raising steam than to get producer gas produced for working a gas engine: can you not effect the result more rapidly?—I think you can.

13605. Therefore in that way the petroleum engine would have an advantage over the gas-fired engine?—I think it would.

(*Chairman.*) But that was not quite what I had in my mind. Supposing instead of your steam boilers, you raised your electricity by means of gas engines: an additional spare gas engine or two would meet your demand more promptly even than the oil?

(*Dr. Le Neve Foster.*) But you must have the additional gas.

(*Chairman.*) Well, you would have it.

(*Dr. Le Neve Foster.*) If you were getting it from the main you would, but if you were producing it you would not.

13606. (*Chairman.*) Quite so: I meant that. Of course, you might have it in internal combustion and still use the petroleum?—Yes, I think that is what will come to a very large extent. The fact is whether we use either coal or petroleum we cannot afford any longer to use our fuel in the wasteful fashion which has hitherto prevailed. I think that is very obvious.

13607. You have no doubt that it is being to a large extent wastefully used?—Yes, I am sure of that.

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TWENTY-THIRD DAY.

Wednesday, 29th April 1903.

PRESENT:

The CHAIRMAN.

Sir GEORGE ARMYTAGE.
Mr. BELL.
Mr. BRIGGS.
Professor DIXON.
Mr. J. S. DIXON.
Dr. LE NEVE FOSTER.
Professor HULL.
Mr. TEALL.
Mr. YOUNG.

The Secretary.
The Assistant Secretary.

Mr. THOMAS URQUHART, called; and Examined.

Mr. Thomas Urquhart.

29 April 1903

13608. (*Chairman.*) You are a member of the Institution of Civil Engineers, and you have had a large experience of oil fuel for locomotive purposes, I understand?—Yes, my Lord.

13609. At what date did you introduce the use of oil fuel into Russia?—My first experience of the introduction of liquid fuel into Russia in locomotives for commercial purposes was in 1883; and it became established in the country in the beginning of 1884. The original trial experiments were begun in 1873.

13610. Will you tell us the line of railway with which you were connected?—The Grazi and Tsaritsin Railway, in south-east Russia.

13611. Since 1884 you have had considerable experience with this oil fuel?—It has been the only fuel used on their locomotives since that date.

13612. Is the use of it extending, do you think, even now?—The railway of Grazi and Tsaritsin of course has been the first in Russia which has been fitted with this system, but other railways further north and west of this portion of the Empire were also fitted with petroleum fuel appliances, and the latest news I have had is that there are over 4,000 locomotives in the Empire now burning liquid oil.

13613. That is in Russia alone, is it?—Yes.

13614. Are the locomotives available for either oil or other fuel, or are they constructed for the use of oil only?—The locomotives that we had on our railway, in fact all the locomotives in Russia, are not built specially for oil fuel; they are simply ordinary locomotives, but they have their fire boxes fitted with appliances for liquid fuel which can be easily taken out in a few hours and replaced by furnace bars.

13615. Is any difficulty found with the oil fuel as regards its effect upon the boiler plates or upon the construction work of the boiler?—None whatever, my Lord, as long as we use brick-lining inside the fire-boxes.

13616. Is the life of the boiler as long with oil as with coal?—The use of liquid fuel is even less injurious to the boiler than the use of coal.

13617. (*Sir George Armytage.*) There is less corrosion?—Yes.

13618. (*Chairman.*) Is there any particular kind of oil that is better than others for fuel purposes?—The principal oil that we used for the purpose of fuel was called astatki, which means in the Russian language the refuse after the paraffin is taken out of the crude petroleum. At the time when I lived in Russia, we had about 30 per cent. of paraffin taken out of the crude oil, which left 70 per cent. of the refuse or astatki; this we used as fuel, so that we did not use crude petroleum direct.

13619. For the purposes of fuel was it better or worse after having had the paraffin taken out of it?—It must have been worse, because the most inflammable part was already taken out by the distillation

13620. In making your calculations of the relative cost, how do the prices compare?—We managed to bring the cost down ultimately to about half of what coal cost us, but the coal we used was simply Russian coal which came from South Russia from the district of the Sea of Azof; we had no English coal whatever.

13621. Is that coal as good as English coal?—Well, it is anthracite that we used mostly, which is very injurious to the boilers.

13622. Is anthracite more injurious to boilers than other kinds of coal?—Yes, my Lord.

13623. Is there any particular reason for that which you could explain?—It is a very hard coal, almost pure carbon, and when it gets into an excessive heat it is very apt to melt the copper plates or other parts of the boiler.

13624. Does it cake?—It never cakes; it is perfectly dry.

13625. What would be the price of oil? Do you make your calculations per lb., or per ton, or in what form?—In the papers which I read before the Institution of Mechanical Engineers in 1884 and 1889, and which I have handed in, I brought it out per mile for the purposes of information for the Institution.

13626. But can you tell us, in order that we may follow it, what the relative prices per ton are?—There is a Table which is to be found at page 297 in the Proceedings of the Institution of Mechanical Engineers for August 1884, which shows that anthracite burnt per train mile 43lbs., and petroleum refuse 25lbs.

13627. Could you tell us what the relative cost per ton of the petroleum refuse and the coal respectively would be?—Upon referring to the table at page 56 in the Proceedings of the Institution of Mechanical Engineers for January, 1889, it will be seen that the yearly cost is summarised for each of the two years, 1882 and 1887; the cost of petroleum refuse per ton in 1882–3 in barges at Tsaritsin was 21s.*; in 1885 it was 17s. 5d.; and at the end of 1887 it had fallen to 13s. 7d.

13628. Could you tell us for those periods what the relative cost of coal per ton was?—The price is given at page 56: "Consumption and cost of coal in 1882 and of

*The mean results of the comparative trials for the whole year 1883 with engines, six wheels coupled, working goods trains were as follows:—Coal consumption per train mile 69·80 lbs. as compared with 43·19 lbs. of petroleum, at a cost of 10·212 pence for coal and 5·495 pence for petroleum; being an advantage of 38 per cent. in weight and 46 per cent. in cost in favour of petroleum. Of the coal used 49 per cent. was semi-anthracite not very pure and 51 per cent. was bituminous coal. The mean prices of fuel for the year were—petroleum refuse 23s. 4d. per ton, coal 27s. per ton. The 21s. for petroleum given in Question 13627 was the price in the early part of the year 1883. Proceedings Inst. Mech. Eng., August 1884, pp. 287 and 296.

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petroleum refuse in 1887, per engine mile, in a six-wheel coupled 36-ton goods locomotive on the Grazi and Tsaritsin Railway. Coal cost on an average for the whole year 7·6d. per train mile."

13629. (*Sir George Armytage.*) Per engine mile?—Per engine mile. Petroleum in 1887 cost 4·4d. per engine mile.

13630. Coal 7·6d., and petroleum 4·4d.?—Yes.

13631. (*Mr. Young.*) Could you say what the price of coal was in those two periods—1882 and 1887?—Of course the consumption of coal was taken for the year 1882 only. No petroleum whatever was used in that year, and so again the consumption of petroleum refers to 1887 only.

(*Mr. Young.*) The price of coal is 10 per cent. higher, my Lord.

13632. (*Chairman.*) Yes, I have been trying to get that. You have not got the price per ton; you have already told us that in 1885 the cost of petroleum was 17s. 5d. per ton, but we have not been able to ascertain what the cost of coal was per ton?—I should be very pleased to let you know if I could find it in the paper.

13633. When you spoke of 17s. 5d. per ton in the barges, did you speak of the crude oil or the astatki?—Astatki.

13634. That is with the paraffin taken out—30 per cent. taken out?—Yes. I did on one occasion try crude oil, but we found no practical benefit.

13635. Is the astatki with the 30 per cent. taken out obtainable at a less cost per ton than the crude oil itself? Yes, my Lord.

13636. In other words, the value of the paraffin taken out is greater than the cost of taking it out, and it leaves the residue at a less cost per ton, does it?—Yes, because there is such a large quantity of residue—70 per cent. of the whole product of crude oil, which they had a great difficulty in getting a market for, and consequently it became very cheap. It may be different now, because there is a greater demand for it.

13637. We had better perhaps find the cost per ton of coal because that is necessary in order to compare the figures. It is stated in the Proceedings of the Institution of Mechanical Engineers for 1884 that "Mr. Urquhart has sent the following reply to the observations made in the discussion," which is the discussion on the paper. Then page 320 "In explanation of Mr. Tomlinson's remark that in the south-eastern portion of Russia there is no coal, the fact is that, although coal does exist there in great quantity—the centre of the anthracite basin being Grooshefka, near the town of Nov-Tcherkask on the River Don, not far from the Sea of Azof—yet the distance to Grazi"——That is our junction with the main line.

13638. "the western terminus of the Grazi and Tsaritsin Railway, is no less than 420 miles. Hence, while last year the cost at the mines was 9½ copeks per pood loaded on trucks, equivalent to 11s. 9d. per ton, the mean cost on the line is 27s. per ton. because transport and other dues amount to as much as 15s. 3d. per ton." Therefore in 1883 the cost of the coal, at all events at the point of consumption, was 27s. per ton?—Yes, my Lord, and it probably would be about the same price throughout the period covered by my papers.

13639. What would be the cost of the astatki at the point of consumption? You have given it at 17s. 5d. in the barges?—In the barges on the Volga.

13640. Then, would it have to be carried any distance?—It would be carried inland for consumption say, for instance, to the middle of the line, 250 miles.

13641. That would add something, but not so much as the difference between it and coal?—Yes; not so much.

13642. What would be the freight that you would reckon from the barge to the middle point of consumption; would it be shillings per ton?—Not so much as that.

13643. Would it be half-a-crown, making the cost £1?—Well, if you put it down as 1s. it would perhaps be safe—in 10-ton trucks.

13644. (*Sir George Armytage.*) Then say 18s.?—I should say it would not be more than 10s. upon the 10 tons, because the railway company charge themselves less than the public; but if it was taken for other people, for outside people, it might cost more. The railway company carry it for their own use.

13645. But we have 17s. 5d. as the price in the barge?—Yes.

13646. We have the price of coal at 27s. practically at the point of consumption?—Yes.

13647. We want to get at what would be the figure to be added to the 17s. 5d. in the barge to bring that astatki or petroleum to the point of consumption. How much would you add to the 17s. 5d. to make it compare with the coal?—I think we should not add more than 1s. 6d. per ton.

13648. That makes, roughly, 19s.; therefore in that case the astatki would be 19s. compared with coal at 27s.?—At the point of consumption.

13649. (*Chairman.*) Have you any knowledge as to how that coal would compare in quality for fuel purposes with English coal. You speak of it as being anthracite; would it at all compare with the anthracite that comes from South Wales?—It is very like Cardiff coal, but a little harder.

13650. Is it of as much value for steam raising purposes?—It is even better, but it is more injurious to the fire boxes; it needs a strong blast to make it burn.

13651. Then we have it that the coal is coal of good quality, and you think that it is as good as the Cardiff coal for steam raising purposes?—Quite as good as the Cardiff coal.

13652. The prices compare therefore as 19s. for the astatki and 27s. for the coal?—Yes, at the point of consumption in 1885.

13653. On that basis you work out the cost as 7·6d. for coal per engine mile and 4·4d. for the petroleum?—Yes.*

13654. That is about as near as we can get for the purpose of comparison. Have you any knowledge as to the relative prices to-day compared with that period?—No, my Lord, I have no knowledge whatever.

13655. But probably for the same materials the relative proportions of cost would be about maintained, would they?—I think it should be about the same; I know the astatki or refuse has gone up in price because there is a much larger demand for it now. They use it in factories up as far as St. Petersburg and Moscow.

13656. What about coal?—Coal from Russian coalfields would not be sent so far; the coal used there would go from this country.

13657. Then you have told us that there is no difficulty in constructing furnaces for the purpose of burning oil or burning coal alternatively, and that the change can be made in a few hours and at a small cost?—The whole arrangements of the construction of the fire-box are shown in these drawings in the papers I have put in, and they are constructed so as to make an ordinary locomotive burn petroleum. The first thing to do is simply to take out the fire bars and to build on the ash pan a frame of fire brick with an arch; then you put on a spray injector for spraying the petroleum into the fire-box. This arch and the brick lining prevent the intense flame doing any injury to the plates of the boiler; at the same time, the bricks get so hot that they act as a fly-wheel for keeping the temperature of the fire-box more or less equal.

13658. Is there any great variation in this astatki in its value as fuel?—We had not the means of controlling what we were getting from the wells in Baku, we simply took it as we got it; we had only one test, namely, specific gravity, but we had no means of defining its chemical contents, so that we took it for granted it was all alike.

13659. But in the practical working of the locomotive, did you find that there was greater difficulty in getting

* The mean cost of the petroleum refuse in 1887 was 26s. 6½d. per ton on the railway, including transport, storage, depreciation of tanks, pumps, pipes, etc., and administration. It was from that basis that the 4. 4d. per engine mile was worked out. Inst. Mech. Eng., Jany. 1889, pp. 39 and 59.

The 19s. referred to in Question 13652 was the cost of petroleum refuse in 1885 at the point of consumption including transport only.

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Mr. Thomas Urquhart.

29 April 1903.

up steam by certain consignments than by others ?—None whatever ; we never discovered any difference.

13660. How is the steam got up ; what is the method of getting up steam in the first instance ?—At all the engine depôts we had one reserve engine always in steam for shunting purposes—the use of the depôt itself ; all the engines were fitted with a tap or coupling, so that we had a small pipe from that reserve engine and could connect it to the cold engine ; supposing we wanted an engine to get up steam, they could just go alongside and couple up the pipe to the engine that had steam ; or if there was a fixed boiler, then we blew the steam into the spray injector in the cold engine, and in a few minutes we had steam enough to make it independent.

13661. How is it lit ?—By throwing a few shavings inside the fire-box, and setting a match to them.

13662. Is there any difficulty in regulating the supply of the oil ?—Not in the least ; it can be more easily regulated than with any other fuel ; you can stop it altogether in a moment.

13663. What determines the supply—the blowing off of the safety valve or the general condition ?—The engine-driver looks at his steam gauge and sees what quantity of steam he has, and he can regulate it accordingly.

13664. He takes the supply off if the steam is getting up, and increases it if the steam is going down ?—Just so.

13665. What are the advantages of oil fuel, in your opinion ? Does it occupy more space or less space than coal ?—It occupies much less space than coal—about half the coal space ; it is much cleaner on the engine ; in fact, one man could manage the whole train. We were obliged to have two men on the engine because the Government did not allow us to have only one, but there was an American who came all the way from Pennsylvania to see what was doing in Russia with petroleum fuel, and he put down the point that he could do with one man in America. I do not know whether the law will allow him to do it there or not.

13666. Have you any knowledge whether the Pennsylvania oil is better or worse than the Russian oil for fuel purposes ?—I have no knowledge, my Lord, of the comparative qualities ; I have had no experience myself with the Pennsylvania oil.

13667. Is there any difference in working in Russia in the winter and in the summer ? The variations of temperature there are greater than here, are they not ?—Yes, my Lord, very much greater : but the only difference that we have in Russia in the winter time is that we are obliged to keep the steam pipe inside the supply pipe from the tender to the spray injector to keep it warm ; otherwise it gets so thick in severe frost that it will not run ; we have to keep it hot.

13668. Is there any trouble with the fouling of the spray injector ?—It is very seldom that it takes place, but there are means provided by which if anything does foul the injector it can be cleaned out in a couple of minutes.

13669. Is there any difficulty as to water getting into the oil tanks ?—None whatever, unless it leaks through from the tender.

13670. The effect of the hot or cold weather is merely a question of thickening or thinning the oil, is it not ?—That is all.

13671. What is done with regard to the storage and distribution of it ? Had you places along the line where it was kept in tanks ?—Yes ; we had a large tank at each engine depôt, say about 200 miles apart.

13672. Was that in the ground or above ground ?—Above ground, my Lord.

13673. And the oil was run into the engine, was it ?—It was pumped up to a higher tank set on a pedestal, so that the tender came alongside and the oil was supplied to the tender in just the same way as water is supplied.

13674. You have given us the consumption per train mile, both as regards weight and cost, have you not ?—Yes, my Lord.

13675. Is oil fuel used to any extent for the generation of steam in stationary boilers in that district ?—Yes, to a very large extent now in Russia ; all the factories about Moscow are now burning petroleum.

13676. Are any of them burning it by means of internal combustion engines, or is it used for the purpose of raising steam ?—Well, for small purposes they may use it in oil engines, but I am not aware of any such use on a large scale.

13677. Is it used for metallurgical purposes ?—Yes, my Lord, it is ; I use it in my own works for metallurgical purposes—for melting brass and welding iron. At our scrap furnaces we roll our iron out into bars all by the use of petroleum fuel.

13678. (*Sir George Armytage.*) How long do you say it takes to change your fire-box from oil to burning coal ?—Well, if a hot engine came in, of course we should have to give it some time to cool down. The hot bricks will take some little time, because you could not put your hands upon them ; but after they have cooled down in three hours you could take the whole thing out and put in the fire bars.

13679. Are your engines so constructed that that can be easily done ?—Very easily done ; in fact, the Government of Russia would not allow us to adopt petroleum fuel unless we could prove that these engines could be made at any moment effective for burning coal.

13680. What number of engines have you on that line ?—143 was the number during my time ; they may have more now.

13681. In what proportion of those engines do you use coal, and in what proportion do you use oil ?—All oil now.

13682. Then there is practically no coal used on that line ?—There is not a pound of coal used.

13683. But there was some used ?—Well, there was during the time that we were introducing the liquid fuel ; of course, we could not alter the engines all in one day, we had to keep coal burning on some of them until we gradually worked into liquid oil fuel only.

13684. From the figures which you have given us I gather that it costs you about 7·6d. per engine mile for the use of coal ?—Yes it did.

13685. And for petroleum you say it costs 4·4d. ?—Yes.

13686. That is giving petroleum at 19s. per ton and coal at 27s. per ton ; is not that so ?—Yes. *See Note to Question 13653.*

13687. Then your saving is apparently about 3·2d. per engine mile ?—About that.

13688. Is that so ?—Yes, according to these tables. These tables are based upon the whole working for one year ; it is not simply an experiment, but the whole working of one year.

13689. What is the weight of oil fuel compared with that of the coal fuel, and what is the capacity, I mean with regard to carrying it ? What I want to know is what amount of space would a certain proportion of oil fuel take which would do the same work as coal occupying the same space ?—I should think, roughly speaking, it is a little over half.

13690. That means that you get the same quantity of oil to do twice the work in the same space as if you had to use coal ?—Yes.

13691. I take it that in other parts of Russia they use coal almost exclusively, do they not ?—In the extreme south they do use coal near the coal pits.

13692. Then it becomes only a question of price as to which is the most economical at the particular point ?—Simply a question of price.

13693. That is to say, that if the railway happens to be situate in a coal district it would then be cheaper to use coal than to use oil ?—I should think it would be cheaper to use coal, because the transport in Russia is excessive ; the distances are very long and there is a very high tariff.

13694. Then the whole thing turns upon the price of fuel at the particular point ?—That is so.

13695. (*Chairman.*) I did not ask you whether oil makes any smoke ?—Well, smoke can be made if one wishes to make it, but by using a brick lining and the brick arrangement inside the fire-box, and by careful manipulation

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and heating up the brickwork to some extent before you put on the full force of the blast, you can burn the smoke completely.

13696. It is a question of combustion, is it ?—Yes.

13697. (*Professor Dixon.*) How is the air drawn in for burning the oil in these engines ?—I used simply a spray injector, and the internal nozzle is a steam one and the next nozzle an air one.

13698. So that it is practically an injector ?—Yes, an injector. The whole arrangement is shown in the Proceedings of the Institution of Mechanical Engineers 1884 and 1889, where there are a large number of diagrams and sections.

13699. It is a steam, air, and oil injector ?—Yes, a steam, air, and oil injector. That, however, was not the only supply of air ; we had dampers beneath in the fire-box also.

13700. But you believe in steam with the oil and air ?—Well, it causes induction itself.

13701. On the injector principle ?—Yes.

13702. Can you regulate the supply of air by the nozzles ?—I had no means of regulating the supply of air, because we never had enough from that source ; we always had an augmentative supply by ordinary bars in the ashpit.

13703. Then sometimes you had smoke, I gather ?—We could always keep it down ; if there was smoke it was simply through the carelessness of the engine-driver. Of course, while the brickwork is green, that is to say, not hot enough, you would get smoke ; but when you get the brickwork up to a certain temperature, you can do away entirely with the smoke.

13704. Is the same oil being used now ?—Yes, the same oil ; the only difference that I know of is that they have made improvements in the distillation of paraffin, and that they have taken more out of the crude oil than they did in my day. Thirty per cent. was taken out of the crude oil when I was there ; that is about 12 years ago. I believe they are taking more paraffin out of the crude oil than they did hitherto, and that makes the refuse thicker and leaves less of it.

13705. Except for the fire-bricks and the plates you have described, the rest of the furnace and boiler was like an ordinary one ?—Like an ordinary boiler ; we had not to bore a single hole into it, but simply to take out the bars—that is all.

13706. Have you also had experience of marine engines fired with oil ?—I have had no experience myself, but I have seen boats on the Volga fired by oil.

13707. Were those fitted with water tube boilers or cylindrical boilers ?—Ordinary Scotch boilers.

13708. (*Dr. Le Neve Foster.*) Of what consistency is this astatki at the ordinary temperature, we will say 60° ?—The table which I have before me in the Proceedings of the Institution of Mechanical Engineers for 1884, page 274, gives the analysis of Pennsylvanian and Russian crude petroleum oil : the carbon in Pennsylvanian crude petroleum oil was 84·9 per cent., of hydrogen 13·7 per cent., and of oxygen 1·4 per cent. Then in Russian naphtha refuse (that is our astatki) the carbon is given as 87·1 per cent., the hydrogen 11·7 per cent., and oxygen 2·2 per cent. Those are the chemical constituents of the Pennsylvanian and the Russian.

13709. I asked the consistency—the thickness of it ?—In summer time it is as thick as ordinary lubricating oil ; but in the winter time it gets thicker.

13710. Then in winter time does it get so thick that it will not run ?—It gets so thick that we cannot get it to run to the spray injector.

13711. Then how do you start a locomotive in winter time ?—We simply heat up the oil, to begin with.

13712. But how do you heat it up ?—By having a steam spiral pipe into the tender.

13713. But supposing you have got the locomotive cold, how do you start it—you have no steam ?—We have the steam from a neighbouring locomotive.

13714. Ah, if you have the neighbouring one ?—Yes, we always have that at the engine depôt ; there is always one engine in reserve in steam for general use, and all the engines are fitted with the necessary appliances for heating up.

13715. You said that astatki is taken as far as Moscow for use for industrial purposes as a fuel ?—It is.

13716. What distance is it from Baku to Moscow ? I know it is about two nights on the railway ?—It does not come by railway ; it would never pay. They take it all by water to Nijni Novgorod. I could not say exactly the distance, but I should think it is about 700 miles.

13717. It is more than 700 miles.—I may be mistaken but it is all by water carriage.

13718. From Astrakhan up to Nijni Novgorod it takes six days to go in the steamer ?—Yes, it does. I may be mistaken as to the distance ; I know it is a very long distance indeed.

13719. What is the cost of carriage from Moscow to Baku for astatki, do you know?—I do not know the cost.

13720. In the ordinary land boiler would they have a fire-brick lining?—Yes, it is always better when there is a fire-brick lining.

13721. Would they have one in a marine boiler also?—They certainly ought to.

13722. How do you get your blast in the stationary boiler ? Do you inject, do you drive in steam, and then drive in air on the injector principle?—If there is no other steam at hand to force it so that we can benefit by the steam from another boiler, we simply put down a wood fire to make steam sufficient to start the injector.

13723. You said you judged your astatki by the specific gravity?—Yes.

13724. Did you base your price upon the specific gravity in any way?—All that we looked to was that we thought if we had the specific gravity high or low there would be less or more water in it.

13725. What is the usual specific gravity?—The specific gravity at 32 degs. F. of Russian heavy lubricating oil is 0·938, and of Russian naphtha refuse (that is for fuel) 0·926.

13726. Do you find that the amount of astatki used in Russia at the present time for locomotives is increasing?—Well, all the railways that can find it more commercially economical for themselves as compared to local wood or coal adopt it, but where wood compares more favourably they adopt the wood, of course.

13727. Has not the amount of coal raised from the Donetz Basin increased immensely since you were there?—It has very much increased, and it has so far increased that a great many steam boats are now supplied with it on the Black Sea.

13728. The point I was coming to was this: has the increase in the output of coal from the Donetz Basin affected the use of astatki to a certain extent?—I do not think it has, because I learn that nearly all the factories right up as far as St. Petersburg prefer astatki, and it is much more economical to use astatki ; but I do believe that there is an outlet for coal in steamboats now which there has not been hitherto.

13729. As a matter of fact most of the steamers on the Black Sea are fed with coal?—They are fed with coal, I believe.

13730. And the Caspian Sea steamers all use astatki?—The Caspian steamers all use oil and all the Volga steamers use oil also.

13731. (*Mr. J. S. Dixon.*) These costs which you gave us of 7·6d. and 4·4d. for coal and oil, I suppose, are applied to the circumstances of the place where this was done?—It is the general average over the whole length.

13732. But as applied to Russia?—Only in Russia—on our own railway.

13733. I do not suppose you would compare in this country the question of using oil as against coal?—I did not make any comparison in this country.

13734. The circumstances here would not warrant the idea of applying oil to steam raising in this country, would they ?—Well, if oil would come out cheaper than local coal they might use it here.

13735. But you know the general price of coal in this country ; do you think there is any chance of oil being

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Mr. Thomas Urquhart.

29 April 1903.

used in substitution for coal here?—I do not think at the present prices of coal there would be any profit in using oil in this country.

13736. Then you think that any saving in the consumption of coal (which is the question we are considering here) is abroad, where the circumstances are favourable?—Certainly. I have no idea what the oil costs in this country, but I have a fair idea of what the coal costs. I should think that taking oil from Baku or America to this country and comparing the cost with coal, the coal would stand a chance of being more economical.

13737. Do you know whether British coal has been supplanted at any of the Russian mills or works or on the railways by this oil?—I am not aware of any English coal being supplanted by petroleum in the north of Russia.

13738. Or elsewhere?—Or elsewhere.

13739. Because what we want to know is whether this oil is likely to save the coal in this country. Do you think that is likely to be the case, that the coal which was formerly exported for industrial purposes abroad is likely to be supplanted by the use of oil?—I have had experience in St. Petersburg where we use English coal for our works in very large quantities, but then the coal all comes by the Baltic in ships from Newcastle to our place. But I do not think that the petroleum from south Russia would be able to compare favourably with coal from this country even in St. Petersburg.

13740. There is not likely to be a saving of the resources of Great Britain's coal?—I do not think so—it is too long a distance.

13741. (*Chairman.*) There is no oil in north Russia, is there?—None, my Lord, it is all in Baku—the Caucasus.

13742. (*Dr. Le Neve Foster.*) Has not some been found in north Russia?—I have never heard of any being found there.

(*Dr. Le Neve Foster.*) I think it has been found there.

13743. (*Mr. Briggs.*) I should like to ask you about the brick arches and linings; did you find they required constant renewal, or did they stand well?—Once they get heated up, to begin with, they take a glazing on, and that binds them more or less together; but my experience is that fire bricks are very varied in their constitution; some bricks will stand very well, and others will not. There is a brick, that I know very well, which stands very well in gas furnaces—the Dinas brick; it stands an enormous temperature, but you must keep it always at that temperature, and it would not do for locomotives, because the temperature fluctuates too much. The best brick I have found in my experience was a brick made in Scotland (the Glenboig); it is an elastic brick.

13744. Did you get most of your bricks either from this country or from some outside source?—We got them from Scotland—Glenboig. After a few years' experience of the petroleum fuel we found the Glenboig brick would keep the best, and we kept to them.

13745. That is to say, they would stand heating up and cooling down without crumbling to pieces?—Yes.

13746. And that is more important than a refractory brick?—Yes.

13747. (*Mr. Young.*) How were the vessels which held the oil, from which the locomotives got the oil, fed on your lines?—We generally had the main reservoir on a hill or elevation above the tender, and we had a smaller reservoir for supplying the tender.

13748. But how do you get the oil into the large well?—By gravitation.

13749. Down pipes?—Yes.

13750. From Baku?—Oh, from Baku we had it delivered in tank steamers to the end of our railway, which is called Tsaritsin, on the Volga; we had it delivered there and pumped from the tank steamers or tank barges through pipes up to a high elevation on the River Volga into large reservoirs which contained perhaps 200,000 poods of refuse.

13751. What would be about the distance from Baku to St. Petersburg?—I am afraid I cannot give you the exact distance.

13752. What would the carriage of oil be from there?—I have no idea.

13753. (*Mr. Bell.*) I believe in the south of Russia there is a very large import duty on coal, is there not?—I believe there is a very heavy duty, with the object of developing Russian coal.

13754. I think it is about 8s. or 10s. per ton. In the figures that you give of the cost of oil at 19s., giving 4·4d. per mile as against coal at 27s., giving 7·6d.: that is both per ton of oil and coal?—Yes, per ton. *See Note to Question 13653.*

13755. Then it would seem, if you were to reduce the price of coal per ton to something like the price of oil per ton, you would get practically the same cost per train mile?—Well, you see we could not get the coal cheaper.

13756. No, but I am trying to arrive at the relative cost of running these engines with coal and with oil. If you could get your coal at 17s. 2d. per ton, for instance, the cost per mile would be 4·4d.?—Yes, I quite understand you now—if the original cost of coal was as low as the oil cost.

13757. Yes, per ton—the result would be about the same?—Yes, about the same.

13758. We have had evidence telling us that you get double the power out of the same weight of oil?—That has been my experience; I find that a ton of oil goes nearly as far as two tons of coal.

(*Mr. Bell.*) That does not seem to compare with these figures.

(*Chairman.*) I do not quite gather what the point is; but it seemed to me at the time that if you increase the price of the oil to what it is here, and reduce the price of the coal to what it is here, the effect would be as you say.

(*Mr. Bell.*) Coal at 17s. 2d. per ton, according to my figure, would give a train mile cost of 4·5d.

(*Mr. Briggs.*) Did not the witness say that the amount of oil to occupy a given space would produce twice the power of the amount of coal? He did not say a ton. I took his evidence to mean that the storage of the oil, owing to its being a liquid, occupied so much less space; not that it was a matter of weight.

(*Chairman.*) Agreed, but previous witnesses have stated (and I think probably we shall hear it stated again to-day) that you can get, *quâ* power, nearly double from a ton of oil what you can get from a ton of coal.

(*The Witness.*) That is so, my Lord, with a locomotive in first class order and in the hands of a skilful driver; 50 tons of petroleum are equal to 100 tons of first-class coal.

(*Chairman.*) Whereas, as Mr. Bell points out, according to the witness' figures the difference in cost practically only represents the difference in shillings per ton.

(*Mr. Young.*) May the difference not arise from one being pure oil and the other oil refuse?

(*Chairman.*) No; apparently they are on the same basis, because I take it that the oil that we get in this country in the majority of cases, or in many cases, has had the paraffin taken out.

13759. Some of it may be in its crude state; but you told us that you found very little difference between the crude oil and the astatki?—I found very little difference, my Lord, in the use of the crude oil. It is more dangerous to use. There is one explanation I wish to make. The table with the figure of 7·64d. is for six-wheel locomotives, and there is another table alongside that one for eight-wheel locomotives. The comparison there is 11d. per engine mile, and 5·8d.; there are two classes of locomotives, one a six-wheel locomotive and the other an eight-wheel locomotive.

13760. But the eight-wheel locomotive would pull a heavier train, would it not?—A heavier load, yes.

(*Mr. Bell.*) The relative figures are about the same, I should think.

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Mr. JAMES HOLDEN, called; and Examined.

13761. (*Chairman.*) You are a member of the Institution of Civil Engineers and a member of the Institution of Mechanical Engineers?—I am.

13762. For the past 18 years you have been Locomotive, Carriage, and Wagon Superintendent of the Great Eastern Railway?—Yes.

13763. Will you tell us how many engines the Great Eastern Railway Company has?—About 1,200.

13764. And how many train miles do they run?—22,000,000 per year.

13765. What is the consumption of coal?—About 650,000 tons per annum.

13766. Does that mean for the 1,200 engines—because you are going to tell us something about oil fuel?—Some of them may not be running.

13767. But that, roughly, is your consumption of coal?—Yes.

13768. You have applied, as we know, oil as fuel to quite a considerable number of your engines, have you not?—Yes, about 80 of them.

13769. How long has that oil fuel been in use?—I began about sixteen years ago, or nearly seventeen years ago.

13770. May we take it that for that period you have been rather improving the means of applying and dealing with oil fuel?—That is so.

13771. Therefore probably you would say that you could get quite as much, if not more, out of oil now than at any previous time?—Yes.

13772. How does it compare for cost?—I only buy as much as I can get at slightly more than twice the price of coal. I am not confined to the use of oil.

13773. Would you use oil if you could get it at twice the cost of coal?—Yes; if we could get an assured supply at twice the price of coal, I would recommend my directors at once to fit up a large number of engines.

13774. Are you speaking now of what is called crude oil or of the residuum after certain portions of the paraffin have been taken out?—Of the residuum, after certain portions of the distillates have been taken off—the first two or three distillates.

13775. Do you buy that simply because it is cheaper, or because it is cheaper and safer?—I think it is cheaper and as safe—I should not like to say safer—and much more convenient.

13776. Convenient in what sense?—It is much easier to take it on board the tender; it gives no labour to the fireman; it gives him practically the whole of his time to look out for signals and to attend to other work on the engine; it is very much more convenient for storage purposes. Coal costs us about 4d. per ton to put into stack and 4d. per ton to take out, and there is a depreciation upon coal of about 2d. per ton per annum.

13777. Is that by deterioration?—By atmospheric distillation.

13778. Does that apply to all coal?—It applies to all coal such as we are in the habit of using. I have had little to do with anthracite, the stone coal of the United States, so that I cannot say how it would apply in every case; but, as a matter of fact, we tested very accurately about 3,000 tons of coal some years ago for the purpose of ascertaining what the depreciation was. It was something more than an estimate, for we took fresh coal and compared that, the conditions being as nearly as possible equal in all respects, with coal that had been in stack for a long time.

13779. The result was that you came to the conclusion that the deterioration represented about 2d. per ton per annum?—Yes. I cannot say what that would be for a long series of years; probably it would be very much accentuated.

13780. I was going to ask you that question as to whether in a period say of 10 years, the deterioration would be uniform throughout the period, or whether the deterioration would take place mainly in the first year or two?—My experience is that it is very much greater; I should not be surprised if it was the square of the number of years. So satisfied am I of that that we have dealt in this way with the coal which we have in stack:—for the last few years we have stacked something like 60,000 or 70,000 tons as a reserve against strikes or difficulties of that kind, and I put it into comparatively small stacks say of 2,000 or 3,000 tons and date them, and we never have it in stack more than 2½ years. At the end of two years we begin to use up the old stacks and we stack fresh, although at some additional cost to ourselves, roughly 9d. or 10d. per ton.

Mr. James Holden.

29 April 1903.

13781. Would you say that that applies equally and uniformly to coal like South Yorkshire, Derbyshire, and Nottinghamshire coal?—I am speaking particularly of those coals; they are the coals that we stack and that we mainly use.

13782. And you are satisfied from your experiments that even at the end of two years there has been some deterioration, and that beyond that period the coal really would be less valuable for the purpose for which you use it—I am quite satisfied about that.

13783. And therefore that it pays you to incur the cost, as I understand you, of 4d. per ton for putting it down, and 4d. per ton for picking it up; that is 8d. per ton?—And the depreciation.

13784. Yes, and the depreciation; therefore that is 1s. per ton really for two years?—That is so.

13785. Do you arrive at that conclusion from what I will call the working tests of the engines as far as you can judge, and from them only, or have you made any analysis or any chemical tests?—Checked by the laboratory tests. One always prefers to rely mainly upon a practical test, and it is a common excuse on the part of the driver who loses time, if he has had coal out of a stack, to attribute it to the fact that his coal came out of stack and therefore caused him some difficulty in maintaining steam.

13786. The tendency is, I suppose, to attribute it to any cause except the real one?—One sometimes does not adopt the driver's view.

(*Mr. Bell.*) What percentage would that 1s. represent?

13787. (*Chairman.*) About 10 per cent.?—You may take the coal roughly on an average at 10s. per ton; perhaps rather more, as we have a longer carriage; we pay approximately £100,000 a year for toll on coal over the lines of other companies.

13788. (*Mr. Bell.*) Do you ever lay it in stock at times when you think it is cheap?—No.

13789. Only for a sort of insurance?—Yes, an insurance.

13790. (*Chairman.*) You have told us that you have about 80 engines working with oil. By the way do they do for fast work as well as for the heavy work?—I am not able to do very much with any other work, because the liquid fuel is so much more valuable for fast work that I use it almost exclusively for our fastest expresses. When we have to convey Royalty, or when we have any special function on, one always selects a liquid fuel engine; there is never any difficulty in maintaining steam and never any difficulty by reason of getting a dirty fire.

13791. Is there no smoke?—If there is any smoke it is because of mismanagement on the part of the driver; there is not the slightest reason why there should be any emission whatever of smoke.

13792. Do you use any of them in London?—Yes, they are constantly running in and out of Liverpool Street.

13793. Have you ever been fined because of the liquid fuel engines making smoke?—Never.

13794. Did you find a difficulty in the early part of the year 1886 in getting rid of the tar from the Company's gas works?—Yes, the tar from the oil gas. You see you cannot compress coal-gas; it throws down its carbon and you get a non-luminous flame, and as we have to compress the gas for the convenience of storing it under the carriages we are obliged to use a heavy oil which will retain a very large percentage of its carbon and therefore give a luminous flame.

13795. What did you do to get rid of the tar?—I tried to burn it in the open in the first place, but we

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Mr. James Holden.

29 April 1903.

made so much smoke that although it was mixed with sawdust I got many complaints.

13796. Did you discover some plan then by which you could use it?—I experimented under the retorts in the gas-works, and found that I had no difficulty in burning it there.

13797. Was this sprayed in any way or was it merely thrown on?—It was sprayed very roughly; a piece of gas pipe with a steam jet coming in was directed towards the nozzle—a very much less complete apparatus than we use at present. Then I applied its use to the boiler that works the compressing pumps in the gas-works.

13798. Using it wholly for that purpose do you mean?—With a coal base. It was so satisfactory there that I fitted it on to a locomotive also with a coal base, and used it as an auxiliary to the coal. I had no idea of doing anything else but getting rid of this gas tar, and it gave such satisfactory results, that I fitted it on to a number of engines, and from that time we have been increasing the number of engines and the user of oil fuel to the extent that I have indicated, namely, all that we could buy at a price, about twice the price of coal—not much beyond.

13799. And you use, of course, all the tar that you make at your own works?—Yes, and we purchase a great deal. I purchase coal tar from country stations; I have used shale oil, furnace oil, creosote oil, and a good deal of astatki and Texas oil; I have used Borneo oil—anything in the shape of liquid hydrocarbon.

13800. (*Professor Dixon.*) Do you mix them together?—It is very rare that one can mix them together, because of the different specific gravities.

13801. Will they not mix?—No, if they are allowed to stand the heavier oil sinks to the bottom.

13802. (*Chairman.*) Do you use them indiscriminately or alternately?—We use the best for the best work. If we had got Russian astatki or Texas oil, we should certainly use that for our fastest and heaviest trains.

13803. Do you find that weight for weight—the liquid fuel has approximately twice the calorific value of coal?—That is so.

13804. And that it can be advantageously used either alone or as an auxiliary to the coal?—Yes; for the last eight or nine years, I have been using it very largely independently of coal—just using a small quantity of coal to light up, covering the bars with broken fire bricks; we have a lot of fire-brick débris from brick arches which are used in the fire-box of the engine, and which have fallen down; we crack them up, and cover the bars with the pieces, and that makes an incandescent base quite sufficient to use the liquid fuel upon. I do not know that it would be necessary to do that if we had got an assured supply of fuel, but I started with the assumption, and I still feel it incumbent upon me to assume, that I may be called upon at any moment to discontinue the use of liquid fuel, and fall back upon coal in consequence of the market failing us.

13805. Does that mean that you have more or less temporary expedients for the burning of oil, so that you could revert easily to the burning of coal?—I should not call that a temporary expedient. I use fire-bars which have spaces between them, and some of the oil might fall through into the ash-pan if we had not something to receive it upon. Besides, the fire-brick does form an accumulator, so to speak: a reservoir of heat sufficient to enable you to stay for the short time that you would be detained at a roadside station. When we are going to stay any length of time, such as at a terminal station, we throw a lump of coal in, just to maintain the incandescence for the time that we are waiting at the station.

13806. Supposing that you were assured of the supply of oil, and that you could depend upon it for the next ten years, and you would be using oil only for those engines, would you have the fire-box constructed as you have it now with fire-bars and so on?—I should probably discontinue the fire-bars, and put in a solid bottom.

13807. (*Professor Hull.*) Is the oil injected into the furnace?—It is.

13808. (*Chairman.*) It is sprayed in?—Yes, sprayed in. In order to burn it to the greatest advantage, it is necessary to atomise it to the very utmost degree, and also to mix it with sufficient oxygen for its consumption, so that, in fact, it is a very combustible compound, almost in that form an explosive compound.

13809. (*Professor Hull.*) The oxygen is from the air, I suppose?—Yes, from the air. We have a regulable supply of liquid fuel, and a regulable supply of atmospheric air.

13810. (*Chairman.*) Independently one of the other?—Yes.

13811. And therefore you could increase or diminish the supply of either?—Yes, that is so. If there is any tendency to smoke, it is merely necessary to apply a little more air.

13812. (*Professor Dixon.*) How do you regulate that?—By a steam jet; it is induced air—it is not compressed air.

13813. By an injector?—I have a drawing which will show it. (*The Witness produced drawing*). There is an independent ring *A* shown where a jet of steam comes in into this annular space *B*, and there are very minute holes, causing a jet of steam to come out, which induces an air supply. A copper ferrule *C* is screwed through the back plate of the boiler and the back plate of the fire box and rivetted down on either side; the nose of the injector comes into that ferrule. *Supplement Plate 17.*

13814. (*Mr. Briggs.*) Is that below the footplate?—That is below the footplate, so that it does not interfere with the driver at all. The steam comes through into the ring *A* which is shown in section, and the little jets of steam coming through tend to further pulverise or atomise the fuel, and also to increase the induced air supply.

13815. (*Chairman.*) Where does it get the air from?—From the surrounding atmosphere, my Lord.

(*Chairman.*) Through the little holes.

13816. (*Mr. J. S. Dixon.*) The air is flowing all round it?—That is it.

13817. (*Professor Dixon.*) It is not an air injector really; there is no ring for air supply?—It is not an air injector; it is a fuel injector and there is some air coming through. This apparatus at *D* I use for some trains which we have, which have a vacuum brake as well as the Westinghouse brake, and we make use of the injector instead of a pump or ejector for exhausting the vacuum brake apparatus; so that the tail of the injector acts as an ejector for the vacuum brake apparatus.

13818. I ask you that because Mr. Urquhart was telling us that in the Russian engines he knew there was air injected through a separate ring, an annular space around it?—Yes.

(*Mr. Briggs.*) There are three spaces; he allowed a further quantity of air to go in through dampers.

13819. (*Professor Dixon.*) Yes, a secondary supply. You do not find that necessary, I understand?—I do.

13820. Does all the air go in through that?—No, I make use of the dampers.

13821. Then this jet is pointing downwards, is it not?—No, it is horizontal, about 12 inches above the fuel.

13822. Do you put a plate or fire-brick or something for it to play against?—I have a few fire-bricks.

13823. You said there were some broken fire-bricks at the bottom?—Yes.

13824. Then what does the jet actually strike against?—(*The Witness produced another drawing*)—The jet strikes against the brick arch *F* and the oil injector is shown in position. *Supplement Plate 18.*

13825. (*Mr. Briggs.*) Is that arch perforated?—No.

13826. It is simply right over?—That is all.

13827. (*Dr. Le Neve Foster.*) Then on these fire-bars you have the broken brick piled up?—Yes, that is a plan of the same thing; there are the two injectors *G* and *H*.

13828. (*Chairman.*) Then the brick arch practically becomes incandescent, too, does it not?—It does, my Lord.

13829. (*Professor Dixon.*) And then that brick arch throws it back and distributes it?—Yes.

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13830. (*Chairman.*) And it protects the steel work, the plates, does it not?—I have never found much difficulty except from an accumulation of unburnt material.

13831. (*Mr. Briggs.*) Sooty matter?—I should say it is more greasy, as though it was solid fuel that had gone against it and had become dried instead of being consumed.

13832. It would be coking actually?—Yes.

13833. (*Sir George Armytage.*) That is a question of regulating the supply, is it not?—Yes; in point of fact we get none on the arch *F* because the brick gets so hot that it consumes it.

13834. (*Mr. Briggs.*) I suppose the flame sucks back into that and comes through the tubes?—Yes, it comes through the tubes. I am fitting all my express engines now with a heating apparatus *J* in the smoke box for heating the air. The air that is supplied comes very largely through those pipes *K* and *L* at the back of the injector; it is brought in at the front of the smoke box at *M*, and is conducted through pipe *N* to the tail of the injector at *D*. (*Describing on drawing.*)

Supplement Plate 17.

13835. (*Chairman.*) It is practically an economiser?—It is an economiser, my Lord.

13836. (*Professor Dixon.*) Are all your engines fitted in that way?—All the more recent ones are.

13837. Since about what date?—I should say the last four years.

13838. Whether you are burning coal or oil you can use that air supply?—Those engines are all used for oil. It would be three years ago that we did that; the first one was exhibited in Paris in 1900.

13839. (*Chairman.*) If you were using that engine for coal, would you leave in that brick arch which you have there?—Yes, my Lord.

13840. (*Professor Dixon.*) That is fixed; I suppose you cannot take it out?—You could take it out, but not without destroying it.

13841. (*Mr. Briggs.*) But it does no harm?—It does no harm.

13842. (*Chairman.*) Have you any difficulty about the bricks?—None whatever, my Lord.

13843. We have heard that some bricks would not stand the heat, but you have had no difficulty about that?—Oh, yes, you may get low quality bricks. We use nothing but Stourbridge bricks of the best quality.

13844. (*Chairman.*) A witness spoke of their being "elastic," which I thought was rather a good term, and he mentioned some bricks that were found to be elastic.

(*Dr. Le Neve Foster.*) Those were Glenboig bricks.

13845. (*Mr. Briggs.*) He said they stood the shrinkage and cooling down?—I have not used them, and consequently I cannot speak to that. We have found no difficulty.

13846. (*Professor Dixon.*) In burning the coal in the engines is there any difficulty in burning it right up to that arch? Do you find a draught there?—Yes.

13847. You find no difficulty?—No. We should clear off the fire-bricks from the bars. It would diminish the grate area to a very small extent.

13848. (*Mr. Briggs.*) Might I ask is that a heating coil (*pointing to drawing*)?—*O* is a heating coil for very cold weather.

Supplement Plate 18.

13849. And *P* is a strainer for pouring in the liquid fuel (*pointing*)?—Yes.

13850. Of course in the case of oil your tender capacity requires to be a good deal less?—Yes. It gives you more space for water with the same tender.

13851. (*Professor Dixon.*) And you fill it up quicker, I suppose?—Yes.

13852. (*Chairman.*) And there is less weight to carry?—Quite so.

13853. Then you set out in your proof certain specific gravities and flash points of different materials. You use from time to time all these materials—creosote, coal gas tar, oil gas tar, green oil. What is green oil?—One of the products of tar distillation.

13854. Then blast furnace oil, astatki, Borneo oil, Texas oil. They vary apparently in their specific gravity, creosote being 1·075 at 60° Fahr., coal gas tar 1·220 oil gas tar 1·070, green oil 1·115, blast furnace oil 1·000, astatki 0·900, Borneo 0·960, Texas 0·935. The astatki is the lowest in the specific gravity, is it not?—Yes.

13855. Then the flash points range from 120° (close test), which is the oil gas tar, to 220°?—Yes, 120° to 220°. Creosote is 180°, coal gas tar 150°, green oil 220°, blast furnace oil 180°, astatki 200°, Borneo oil 170°, Texas oil 150°.

13856. The highest, namely, 220°, being the green oil?—Yes.

13857. The flash point of the astatki is apparently 200°?—Yes.

13858. That you deem to be pretty safe, do you not?—Quite safe.

13859. Do you think 150° is fairly safe?—Perfectly safe; we have never had an approach to an accident during the whole of the 16 years that we have been using it.

13860. You have had no leakage perhaps?—I do not think that leakage would be dangerous.

13861. Would leakage be dangerous in a ship?—I should think it would be dangerous if there was a leakage in large quantities, but it would be from accumulation of gas, and not from the oil itself.

13862. Therefore that would be a danger, or might be a danger in a ship where it would not be a danger on a railway?—I should not think the mere oil itself would be a danger even on board a ship, except for the gas that might come off it.

13863. The supply of home produced liquid fuel is limited, is it not?—Very limited indeed.

13864. Do you use any of home production?—Yes, I use furnace oil which we get from Scotland; I use gas tar from the country gas-works on the Great Eastern system, and the refuse that I get from tar distillers in the shape of green oil and things of that kind, but it is a very limited supply. I have also purchased from time to time oil gas tar from some of the other railway companies, but not very lately—I think they are all using it themselves—those companies that light their carriages with gas.

13865. (*Professor Dixon.*) Upon something like Pintsch's system?—Yes, it is generally known as "Pintsch's system."

13866. (*Dr. Le Neve Foster.*) You are using this oil for what purpose?—For locomotives.

13867. Are other companies using it for locomotives?—I think they use it mainly in their gas-works: they burn it in their gas-works instead of burning coke or coal.

13868. (*Chairman.*) As I understand, you said you had bought from other railway companies gas tar, the product of their oil gas?—That is so.

13869. They not having at that time a use for gas tar——

13870. (*Dr. Le Neve Foster.*) They are now using it themselves?—Yes.

13871. But not for locomotives?—Some companies are using it for locomotives, the Lancashire and Yorkshire, for instance, and the London and North-Western use liquid fuel. I cannot say what class of fuel they are using, but they use locomotives fired with liquid fuel for doing dock work at Liverpool, where there is a large quantity of inflammable material constantly about, such as cotton.

13872. (*Chairman.*) Does it spark less?—It makes no sparks; that is one great advantage of it, my Lord.

13873. Could you say roughly what percentage of the total oil consumption of your 80 oil engines is obtained from abroad and at home respectively?—I have not the figures here, but I should certainly think 80 per cent. is obtained from abroad.

13874. Do you look for any extension of the use of oil for locomotives?—Not until the price comes down. You see we get coal relatively cheap in England. I think our coal at present, including all charges, is only costing us 11s. 4d. per ton, so that I cannot afford to pay more than, at the outside, say 25s. for liquid fuel.

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Mr. James Holden.

29 April 1903.

13875. (*Sir George Armytage.*) That puts you on a par?—Yes.

13876. About double the price per ton?—Yes. There are some advantages, as I have been pointing out, other than the mere calorific value. If you are burning coal in a locomotive, you may start with a full boiler and a full tender with the water heated, and a full fire-box, expecting to run 30 miles before you are stopped; but suppose you are put by into a siding at the end of five miles, you have no alternative but to open your fire-door, shut your damper and let the cold air come through over the coal, with the result that you get leaky tubes. With an oil fired engine you simply shut off your fuel and you have no further difficulty.

13877. (*Chairman.*) You keep everything warm and shut up?—Yes; you would not have to clean your fire, and that would be a very important point on board ship; instead of having to clean the fire they would constantly have a clean fire. Then there are no ashes, which is another great advantage; you never get a dirty fire; you never get any clinker at the bottom choking up your bars and having to be cleaned out. A number of years ago I was asked by Bass's, the Brewers, who were going to take their people from Burton to Scarborough, to take the London contingent down and to run them from London to Scarborough. With an oil-fired engine we ran them not only from London to Scarborough, but we ran them back from Scarborough to London with one supply, and without having to clean the fire at all.

13878. (*Sir George Armytage.*) Then you were able to take oil enough for it?—Yes.

13879. (*Chairman.*) With regard to the storage, do you store it in tanks?—I do.

13880. Underground?—Partly underground and partly above. I bring it in tanks specially constructed for the purpose. Of course, if we had an assured supply I should recommend my directors to put in a pipe line. This drawing shows the tanks that we use for the conveyance of the oil. (*The witness produced drawing.*)

13881. That is a tank on wheels?—A tank on wheels. Then we bring that up to Stratford, where it is emptied from the bottom; we simply open a valve and it goes into an underground tank; from there it is pumped up into some storage tanks about 18 or 20 ft. above the ground, and it is fed into the tanks on the tenders just exactly the same as a small water crane. This drawing shows one of the cranes. (*The Witness produced another drawing.*)

13882. You have no fear of fire specially?—None whatever. It is not inflammable until it is either heated considerably or atomised and mixed with air.

13883. (*Professor Hull.*) Do you mean to say that putting a match to it or a workman's pipe would not set it on fire?—I have done something much more than that; I had some gentlemen from one of the Government Departments (I do not know that I am quite at liberty to say which) at Stratford, and they raised the question of fire. I got a fire brick hot and took it with the tongs and put it into a pail of the liquid fuel that we were using. Of course, there was some white smoke, but it was quenched, exactly the same as it would have been quenched, if it had been put into a pail of water.

13884. (*Mr. J. S. Dixon.*) What was the flash point of that?—I do not remember what that particular oil was; I think it was green oil.

13885. (*Mr. Briggs.*) That is 220°?—About. I am pretty certain it was green oil, but I could not be positive.

13886. (*Chairman.*) Do you use oil fuel for any of your stationary boilers?—Yes; although our stationary boilers are nearly all of a locomotive type. We are very much cramped for room, and if we put a boiler of that type in as a rule we have not even a stand-by; if we want to do anything in the shape of repairs we simply take the one out and put another one down.

13887. Do you use it at all in internal combustion engines in your works?—No, it would not be suitable for that purpose. You want spirit, or at any rate a very much superior class of oil to what we burn—a very much higher class of hydro-carbon than we use for fuel. I use it for melting brass in the brass foundry, both for melting in crucible and for melting in furnace.

13888. With a blow-pipe, I suppose?—We have a furnace where we can melt about 10 cwt. when we want a large casting. I should have used it much more extensively for manufacturing purposes, if I could have got sufficient of it. That difficulty has prevented me from extending its use in the works; it was so valuable to us for fuel purposes for the locomotives.

13889. Are you more favourably placed than other railway companies for obtaining it, *qud* cost?—I was first in the field, and I think probably the offers of what there is come very largely to me.

13890. I meant rather with a view of getting it cheaply from the steamers bringing it?—Possibly we may be. They come into the Thames and they can deliver it into our trucks, although most of it comes by barge to them; but there is the cost of barging it; all those things run up the price very much.

13891. You are not subjected to that heavy toll to other companies which you told us you were subject to with regard to coal?—No, we have a distinct advantage in that way.

13892. Does any of it come to Harwich?—No.

13893. It is mainly London?—Yes.

13894. (*Mr. Briggs.*) But the oil comes to you at the London end, and therefore it is more advantageous: you save haulage of some of your own coal by using it here?—Yes.

13895. (*Chairman.*) What I meant was whether you were so placed that you could send practically to the ship's side and get it direct into your own tanks?—No, we cannot do that.

13896. Are all your storage depôts lit by electricity?—They are.

13897. That is a matter of safety, is it?—That is a safety precaution.

13898. Are the tanks protected in any way?—No.

13899. What about the generation of gas or accumulation of gas?—There we have a strainer going down into the tank and wire gauze straight over the top of the strainer, so that any gas which happened to be fired through carelessness would be outside of the wire gauze, and would not be able to get into the tank.

13900. You mean that if there is any accumulation of gas it passes through the wire gauze?—Yes.

13901. And is held where—is it in the atmosphere?—Yes, and we should have nothing to do to extinguish it but to just put the lid on, and we could put it on and take it off almost in a moment, and the flame would be extinguished.

13902. (*Mr. Briggs.*) It is on the principle of the Davy lamp?—Yes, on the principle of the Davy lamp. The flame is unable to pass through the fine meshes of the wire gauze.

13903. (*Professor Dixon.*) I suppose you have small openings?—A small opening sufficient to get the supply pipe into, or rather the delivery pipe; the pipe that delivers the fuel from the travelling tanks to the stationary tanks.

13904. (*Chairman.*) It answers the double purpose, as I understand, of straining the oil as it is fed into the tank, and of liberating the gas which may accumulate?—That is so.

13905. And the further advantage of which you have told us, of being easily put out if anything happens?—Yes.

13906. Then with regard to the express and goods engines, do you have, in some cases, long cylindrical tanks laid horizontally along the tenders?—Yes.

13907. Is that for additional storage, or is it for convenience?—No, it seemed to be the simplest way of attaching the tanks to the engines, but it left a large amount of room where coal had been stored; and recently I have been putting the tank into the space that is reserved for coal, which is a little more sightly than the other system, and does not disfigure the tender.

13908. But you still keep space for a little coal, I presume?—Yes.

13909. Types of locomotives fitted with your apparatus, I suppose, are in use in various parts of the world?—All over the world.

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13910. In North and South America?—Yes.

13911. France, Sweden, Austria, Germany, Egypt, Cape Colony, and Java are some of the countries in which they are at work?—Yes. I think all the engines and tramways in Java have been fitted.

13912. Do they get oil cheap there?—They get Borneo oil, and I think they have some local supply.

13913. Are the Russian State railways using some of your type?—Yes

13914. And on stationary boilers in the oil-producing district of Baku they are used?—Yes.

13915. And on engines in the Arlberg Tunnel?—Yes.

13916. Where is that?—It is a tunnel going from Bludenz up to Innsbrück. It is a tunnel which it was very difficult to ventilate; it is an arched tunnel, and at certain seasons of the year the wind blows very strongly into the upper end, and they had so much difficulty in ventilating it that on one occasion the driver and fireman of a train came out at the far end insensible. I did not fit up the engines, but I supplied the apparatus for fitting up two engines; I offered to send out to fit them up, but the Austrian State Railway said that they preferred not to use an apparatus which required an Englishman to work it or to fit it, and I think possibly there was something behind their mind in the matter. Shortly after they tried them; they fitted the whole of the twenty-nine engines, which I think is the number at work on the Arlberg section, and they are working to this day. They have worked it very satisfactorily.

13917. Do they make the apparatus themselves?—No, I have supplied it all so far.

13918. (*Professor Hull.*) Is it a patent of yours?—The particular injector that I use is a patent of mine. I have no patent for using liquid fuel *per se* of course.

13919. No, I suppose not.—There is very much less carbonic oxide; there is a practical absence of sulphurous gas, and there is no smoke; consequently the atmosphere is sufficiently pure there to enable them to work the tunnel with immunity.

13920. (*Chairman.*) I think you have already said that you find that the use of liquid fuel is in no way prejudicial to the life of a fire-box or boiler tubes?—On the contrary, with us it has increased the life owing mainly to the absence of attrition and the absence of the sulphurous gas, which has a very deteriorating effect upon copper.

13921. With regard to the use of liquid fuel at sea you have not much experience?—I have practically none.

13922. Do you use it on any of your own steamers by the way?—I had it for some time on a little ferry boat at Woolwich, but unfortunately it necessitated the boat being laid up twice in the year for survey by the Board of Trade instead of once in the year. The Board of Trade were so alarmed at the idea of our using liquid fuel that they insisted upon surveying the boat twice in the year; that was so inconvenient that at the end of five years I said they must either give us a twelve months' certificate or we should take it off; they refused us the twelve months' certificate, and I took it off. Having so much difficulty with that little installation we have never thought of applying it to our main fleet, where, of course, we should be under the Board of Trade regulations.

13923. Does that cautious habit of mind still continue in the Department?—I am not aware whether it does or not, my Lord.

13924. (*Professor Hull.*) Might I ask a question with reference to the Fleet; did you happen to see in either the "Graphic" or the "Illustrated London News" about a couple of weeks ago a picture of one of His Majesty's armoured ships propelled by liquid fuel?—Yes.

13925. The picture showed that the air was enveloped in an enormous cloud of smoke as a consequence of the use of that fuel. You saw that picture?—I did.

13926. What do you think of that?—I thought that there had been some grave mismanagement to make so much smoke as that.

13927. (*Sir George Armytage.*) Either on the part of the engineer or the draughtsman?—I should not like to apportion the blame.

13928. (*Professor Hull.*) It might have been on the part of both, but it was a striking picture, we must admit?—Yes; of course that was taken from a photograph and I presume that that was *bonâ fide* smoke. I was rather thinking of the case of a locomotive, but it would not be so with a steamer; with a locomotive it depends upon whether you take your photograph from the light side of the issuing steam or from the dark side; if you took it from the dark side, of course, it would have all the appearance of smoke.

Mr. James Holden.

29 April 1903.

13929. (*Chairman.*) Is liquid fuel for the purposes of steamers convenient for storage, would you say?—Very convenient; it can be stored anywhere.

13930. Do you think that a vessel could remain longer at sea with the same tonnage of fuel?—I think she could remain twice as long at sea.

13931. And with a reduction in the number of firemen?—I regard that as a very essential matter in connection with such craft as torpedo boats, where every pound of weight is a matter of importance; you not only reduce the number of men, but you save their accommodation.

13932. Yes, and make available the space saved for other purposes?—Exactly.

13933. (*Sir George Armytage.*) In the early part of your evidence you said that your engines consumed about 650,000 tons of coal per annum. I suppose that is exclusive of the 80 engines which you have fitted for oil fuel?—The amount of liquid fuel that we use is relatively small.

13934. Is it not put into that figure?—No, it is not put into that total.

13935. What is the amount of liquid fuel you use in those engines?—About 15,000 tons.

13936. How many gallons are there in a ton of liquid fuel?—Roughly, 9 lbs. to the gallon; it would be about 260 gallons.

13937. In round figures you reckon, do you not, somewhere about 1d. per gallon as equivalent to about 10s. per ton?——

13938. (*Chairman.*) No, 1d. per gallon would be £1 per ton.—Yes, £1 per ton. You may take that as approximately correct.

13939. (*Sir George Armytage.*) Then that means that as it goes twice as far, you could afford to pay 1d. to be the equivalent of 10s.; is that so?—1d. would be the equivalent of 10s. per ton of coal.

13940. Then, at about what does yours work out?—Coal?

13941. No, the oil fuel?—I should say, taking it altogether, for some we pay as much as 25s. and even 27s., but it averages about 22s.

13942. (*Chairman.*) Speaking generally, would you say that the cost of handling liquid fuel for your engines all told is greater or less than that of handling coal?—Less, my Lord.

13943. You think it would be less even including the tanks, the pumping, and everything else?—Yes.

13944. (*Sir George Armytage.*) Then you take into account as regards the cost of your coal the stacking and unstacking, and you put down about 2d. a ton for depreciation, do you not?—2d. per ton per annum.

13945. That would vary very much according to the quality of the coal, would it not?—Yes; a soft friable coal would be subject to much more depreciation, but that is a kind of coal that we do not stack; we only stack the harder kinds of coal.

13946. Yorkshire coals, and so forth?—And the better classes of Derbyshire coals.

13947. To what do you attribute the depreciation—frost, rain, sun, or what?—I should say a combination of the three; the frost breaks it up.

13948. The rain wets it and the frost opens it out; is that so?—Yes; and the heat, of course, causes a good deal of distillation.

13949. (*Professor Hull.*) Spontaneous combustion?—Well, you do not get combustion unless you have pyrites in it; we always have it very carefully cleaned from pyrites.

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Mr. James Holden.

29 April 1903.

13950. (*Sir George Armytage.*) Which of the oil fuels is the one you use most of?—The astatki—but recently Texas oil.

13951. And you say astatki is the best for your purposes?—I like it best.

13952. (*Chairman.*) It is cheaper per ton than the American, is it not?—I think it is about the same, my Lord.

13953. (*Sir George Armytage.*) Comparing the use of oil fuel as between a locomotive and a ship, I take it that there would be a very much greater saving in labour in the case of the ship, would there not?—Yes, much.

13954. For the simple reason that you are obliged to have two men on your locomotive—you cannot reduce the staff on your locomotive, but you can immensely reduce the staff on your ship.—That is so.

13955. Is this a standard rule of the Board of Trade that vessels which are fitted with oil fuel have to be inspected twice a year?—I am not aware. Of course, ours was a boat carrying passengers. I do not think that boats which do not carry passengers come under the Board of Trade at all, that is to say, not for that purpose.

13956. Quite so. I understand you to say that you first of all bring this oil out of the ship, and then you put it into the tanks of which you have shown us a drawing which carry it on the railway?—Yes, the travelling tanks.

13957. From them you put it again into your large tanks?—Yes.

13958. From the large tanks you pump it up into your storage tanks, and then you let it fall by gravity into the locomotive tender?—That is so.

13959. Is it possible to take that liquid fuel from the railway truck straight away to your tender without having to go through that process?—Yes, we could easily do that. At the country stations we have one of those trucks, or its equivalent, standing by the side of the road, and the driver attaches a pipe connected with his Westinghouse brake apparatus, and simply brings an air pressure on to the top of the fuel and forces it up into his tender.

13960. Quite so; but the point at which you want to receive it is higher than the truck which you are carrying it in?—Yes.

13961. And therefore you cannot get it by gravity but you must have some pressure to force it up?—Yes. Of course, another way would be to run your tank on a higher level, but that would take up a lot of room, and it would be expensive, considering the small relative use we have.

13962. Quite so; the same as you frequently do with a coal truck?—Yes.

13963. You have not used oil in your steamers at all, you say, except the little one you mentioned?—No.

13964. (*Professor Dixon.*) You said, I think, that when an ordinary train stops at a station with one of these oil-burning engines, they cut off the spray supply?—Yes.

13965. How long does the furnace keep hot, roughly?—It would keep hot for ten minutes or a quarter of an hour, that is, hot enough to fire the fuel when it was re-injected.

13966. But when you were stopping longer than ten minutes, would you throw in a lump of coal?—Either throw in a lump of coal or a bit of wood.

13967. There is no means of keeping just a small jet going, I suppose—that is not convenient?—You could do that.

13968. But it is not done in practice?—I have not done it. I have simply made use of a bit of coal or a bit of wood. We have a good deal of old wood to dispose of from the breaking up of old waggons and the breaking up of old carriages and offal from the saw mills, and it helps to dispose of that in a simple way.

13969. When the engines are standing over night, for instance, I suppose you allow it all to get cold?—Yes.

13970. Then with regard to firing in the morning, is there any difficulty?—None whatever; we put two or three shovels of fire on, and either take steam from another engine or make use of the Westinghouse brake reservoir, if it has got sufficient pressure in it.

13971. Then you keep a reservoir of compressed air?—Yes.

13972. How long does it take as a rule to get up steam—starting cold?—About two hours.

13973. There is not much saving there, then?—I do not think there is any saving in getting up steam.

13974. I suppose the depreciation of coal that you were speaking about really refers to the first year or two in which you have had most experience?—I have had some experience with coal that has been a long time in stack—I was going to say a disastrous experience—I found a lot of coal when I first came to Stratford which had been a long time in stack, some of it nine or ten years, and as a matter of fact when we came to use it, we found our engines stopped in the roads for want of steam.

13975. You have not tried that experiment since, probably?—No.

13976. The 2d. per ton depreciation, I suppose, depends upon more accurate tests than you made with this old coal supply, and tests which have gone on since that period?—I have not tested it since. We tested a large quantity extending over a considerable period by the actual consumption of the working engines; we checked that by a laboratory test or by a series of laboratory tests.

13977. But were those made at the end of one year, two years, and three years, and so on?—Yes, one year, two years, and three years, I think.

13978. So that your figure of 2d. is founded upon that experience?—Yes.

13979. I think you said the furnaces did not want so much repair in the case of oil fuel as with coal?—That is so; there is no sulphur you see, no attrition, and the furnaces are of copper.

13980. Have you not discovered any sulphur?—In the Texas oil there is sulphur; in the astatki there is a mere trace.

13981. There is very little in the astatki, but the Texas has some?—Yes, I was rather nervous about using the Texas oil at first for that reason. I thought in all probability we should have considerable difficulty with it, because the whole of the sulphur would be consumed, whereas with oil having a calcic base I thought some of it would be fixed in the ash; but I tested the Texas fuel most carefully, confining certain engines to it, and I found no deterioration whatever as the result, and I suppose it goes off so freely that it has no effect.

13982. Do you say the furnace is lined with copper?—The furnace is made of copper—that is to say the fire-box of a locomotive is made of copper altogether—sheets of copper.

13983. Does the gas come in contact with it?—Yes.

13984. And yet burning this Texas oil you found no sulphur?—No. I freely admit my surprise, but I found none.

13985. Then it must be very completely burnt. SO_2 I suppose, would not act on copper?—No, I attribute it very much to that.

13986. That is to say, there was no contact of actual sulphur or carbonated sulphur with the metal—there could not be, or you would find copper sulphide?—No, we should find some deterioration as once.

13987. In that particular experience I suppose you have not had any of this greasy matter that you speak about actually on the copper?—No, not on the copper.

13988. That, I think, only came on the fire brick where the jet played?—Yes, on the front plate.

13989. Of course in all that part the copper is completely protected?—Yes.

13990. I think you said that you were making gas largely; that, I suppose, is for compression to light the carriages?—Yes, we make about 24,000,000 cubic feet per year.

13991. What are you making that from?—From a Russian distillate which is generally known as Solar oil.

13992. Something that has been separated from the crude petroleum?—Yes, it is the third distillate, I think.

13993. Rather a heavy oil?—Yes.

13994. Then you are heating the retorts in which this oil is sprayed by means of tar, I think you said?—No, I

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am not doing so; as I explained, I did so in my early experiments.

13995. Now you burn it otherwise?—I burn it otherwise.

13996. I thought I heard you say you burnt tar?—Yes, in my early experiments, that was the very first experiment I made—burning it under the retorts.

13997. And that led you to try it in engines, did it?—That led me to fit up the boiler that we use for compressing gas.

13998. (*Chairman.*) A stationary boiler?—Yes.

13999. (*Professor Dixon.*) That was so satisfactory that you thought of trying it on an engine?—Yes, I then fitted up a locomotive.

14000. I think you said that other companies were using the tar for such a purpose?—Yes.

14001. Then you are using, I suppose, coke for making your gas?—Yes.

14002. I think you also said that very little carbonic oxide was formed in the combustion of the oil?—Well, you see you have such a much larger proportion of hydrogen. I suppose hydrogen would be an ideal fuel if you could get it in commercial quantities.

14003. Yes, if you could compress it?—The next best fuel is a hydro-carbon, where you have less carbon and a considerable quantity of hydrogen.

14004. Then did you not state (I think it was in answer to a question of the Chairman) that comparatively little carbonic oxide was formed as compared with the burning of coal; that was for the same amount of heat produced?—Yes, that is so.

14005. Have you made tests besides the tests you speak about in the Arlberg tunnel: have you made tests in any of your own tunnels?—No; you mean testing the gas?

14006. Yes.—I have tested the effluent gases of the engines, but I am sorry I have not the results here. If it would be interesting to the Commission I could send them.

14007. But you remember the fact that there was a very small proportion of carbonic oxide formed?—Yes.

14008. That is to say, the combustion then is rather more complete, that is the real point?—Yes.

14009. And you lay stress upon that?—Yes.

14010. (*Dr. Le Neve Foster.*) Why have you tested the gases from your locomotives—to see whether the combustion was perfect?—Yes.

14011. Was it pretty perfect?—Yes.

14012. Was there C O formed when you were burning coal, or was there C O given off when you were burning coal?—I do not know that we have ever tested the gases in the coal-burning engines except for the purpose of ascertaining their temperature.

14013. You have not tested their chemical composition?—Not in the coal-burning engines.

14014. What tests have you used, or what tests were used, in the laboratory with regard to the deterioration of the coal?—I cannot tell you.

14015. You do not know whether the calorific power was determined?—The calorific power was decidedly determined.

14016. Have you had any experience of coal kept not in the open, but under a shed?—No.

14017. Or any experience of coal kept under water?—No.

14018. (*Mr. J. S. Dixon.*) Covered over with dust or small coal, or something like that?—No.

14019. (*Dr. Le Neve Foster.*) Then upon another point: Is there any danger with the oil-fired locomotive in the case of a collision? Supposing you have a collision, and your train is set on fire, is there not more danger if you have an oil-fired locomotive than if you have a coal-fired locomotive?—I should not think so; I should think it would be the other way about; in the one case you would have a large quantity of burning coal, and in the other case in all probability the fuel would be shut off; but if it were not, I do not think it would go on burning; and the fuel itself, even supposing the tank was destroyed, would not burn except it was sprayed or heated up to a considerable temperature.

14020. But, as a matter of fact (it is a long time ago), was not that bad Abergele accident due to oil?—Ah, that was petroleum; it was practically an explosive spirit.

14021. (*Chairman.*) It was petroleum oil in casks, was it not?—Yes, the oil that is used for lamps. We do not burn that.

14022. (*Dr. Le Neve Foster.*) I know you are not burning that, but it occurred to me, and one knows what has happened in America, for instance; you have an accident, and the train takes fire?—Yes; in America, I think, the accidents mainly have arisen from the heating apparatus which they have in the carriages—the stove, which has been heated by coke, setting fire to the woodwork of the carriage.

14023. Quite so.—But if you were to pour some liquid fuel out on to the ground—I am speaking of fuel of a class such as we use—and you were to light a match and throw it down upon it, it would not fire it.

14024. No; but if that liquid fuel were to run on to burning wood, would not that accelerate the combustion?—I should say if the woodwork was very hot and very much afire, it might; but if not, I should think the tendency would be the other way—that it would quench it almost like putting water on it.

14025. As a matter of fact, you do not think it is a danger that need to be taken into consideration?—Not at all.

14026. In fact, otherwise you would not use it at all for Royal trains?—We should not use it.

14027. (*Mr. J. S. Dixon.*) I think you have shown that there is no difficulty in using this fuel, but you seem to apprehend great difficulty in getting it in quantities?—That is the only difficulty that I do apprehend.

14028. And you do not know of any large sources of supply that are likely to be tapped for this class of fuel?—Of course, one hoped great things from the Texas supply, but although the price has come down very much indeed, it has not come down sufficiently to enable me to recommend my directors to make a contract over a period say, of five or ten years.

14029. What I want to point out is this: our inquiry is for the purpose of ascertaining whether we can get any enlightenment as to some substance that is likely to be used so as to decrease the consumption of coal, with the object of preserving our resources?—Yes.

14030. So far as your evidence goes, I take it that the use of liquid fuel is not likely to cause a material saving of coal?—If you could get it in quantity, I do not know of a more admirable fuel.

14031. I agree with that exactly; but do you think there is likely to be a sufficient quantity to effect a material saving in the consumption of coal in Great Britain?—I am afraid I am not qualified to speak upon that point.

14032. There is one point which I do not think was alluded to by the Chairman, which I think is a very valuable one, namely, that oil enables coal of an inferior quality to be used?—That is so; you can burn it with a base of wood or a base of peat or lignite or anything of that kind.

14033. Do you think that coals, say the usual coals you burn with 5 per cent. of ash and inferior coals with as much as 15 per cent. of ash, could be made use of by the addition of oil for steam-raising purposes?—Unquestionably.

14034. Then is the tar you use ordinary gas tar?—I use coal tar, the tar which I buy from the gas companies in East Anglia on our own system, which is the ordinary coal tar; and I also use the tar which I get from our own gas works, where we make about 24,000,000 cubic feet per year of heavy gas; we used to make it from shale oil, but we now make it from the solar distillate.

14035. Do you find that ordinary gas tar makes a good fuel?—Oh, excellent.

14036. (*Mr. Briggs.*) It occurs to me that there is a difficulty in using tar and keeping it liquid enough to spray, is there not? Does not the nozzle get blocked up?—No, we strain it.

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Mr. James Holden.

29 April 1903.

14037. And is that sufficient?—That is sufficient. In addition to that, in cold weather we use a steam coil in the tank, and we pass the steam right round it.

14038. Then you think, as far as regards convenience in using, any one of these fuels you have mentioned would do equally well for you?—The calorific value of each is not the same.

14039. But you could use them in the same locomotive, with the same fitting?—Yes.

14040. Whichever happened to be most convenient to you?—Yes. As far as calorific value is concerned, the actual result of burning the various fuels on the Great Eastern Railway is shown in the following Table:—

CALORIFIC VALUE OF LIQUID FUELS.

Fuel.	Lbs. of water evaporated per lb. of fuel.		Percentage of Actual Result to Theoretical Heating Power.
	Theoretical.	Actual Result obtained on Great Eastern Railway locomotives.	
Creosote	17·4	12·5	71·84
Coal gas tar	15·6	11·6	74·36
Oil gas tar	17·8	12·8	71·91
Astatki	21·0	14·0	66·66
Texas oil	20·3	13·5	66·50
Borneo oil	20·3	13·5	66·50
Furnace oil	16·7	12·8	76·65
Green oil	17·3	12·7	73·41

14041. Furnace oil, I suppose, has been made in considerable quantities, and is fairly cheap now, is it not?—Yes, but there is a long carriage on it as far as we are concerned.

14042. You get it by sea, I suppose?—Yes.

14043. Of course to the Caledonian Railway Company, or those who have it on their system, it should be very advantageous?—It should.

14044. Then you have not much residuum left in your tanks after using them for some time?—When we use tar that is so sometimes.

14045. Then I suppose periodically you must empty your tanks and clean them out?—Yes: that is only when we are using tar, or such a thing as green oil, where there is sometimes a little crystallisation.

14046. Yes, but in most of them you can suck up and use whatever solids there may be?—Yes. If we were using Texas oil or astatki we should have no deposit whatever, or practically none.

14047. With regard to the storage question, I suppose there would be no depreciation, at any rate if you store this oil?—No, there would be no depreciation whatever.

14048. And the mere disadvantage of storage is that the tanks would be an expensive matter, and that in getting very large quantities, I suppose you would consider that the interest on the money would be locked up?—Yes. If I were going to store it in large quantities, I should have a big circular tank placed on the ground, and should pump directly into that, by means of a pipe line from the steamer.

14049. And probably you would keep refreshing it, as it were, so that it would always be a storage?—It would always be a storage, and then we should draw from the head that we had got, so that it would be a very cheap method of using it.

14050. Therefore, as compared with coal, on the whole, it is much more advantageous to store?—Oh, much.

14051. And that is another advantage which is, of course, a very great one for you as a railway company?—Yes.

14052. (*Sir George Armytage.*) In that case, you would put your large storage tank at a sufficiently high level, I suppose, to be able to supply your tenders and do your pumping?—We should have a tank 35 or 40 ft. high, so that we should not have to pump until we came to the lower level, say 10ft. high.

14053. Quite so. Your pumping would be done first from the steamer?—Yes.

14054. (*Chairman.*) That means you would make the tank a deeper tank?

14055. (*Sir George Armytage.*) You would put it on a higher level?—Not necessarily put it on a higher level: we should draw from the high level of the storage in the tank, and when we came down to the low level, it would not be a very expensive thing to pump.

14056. (*Chairman.*) You referred to an oil which I think you called solar oil, which you use for gas making?—Yes.

14057. How would that compare as regards calorific value? Have you tried it at all?—It would be much too expensive, my Lord. I think we pay close upon £4 for it. I do not remember whether it is just under £3 or just under £4 that we pay for it.

14058. But it is of better quality, and it is suitable for gas making?—Yes.

14059. Is it better than Scotch oil, for example?—I should not say that it is better than Scotch oil, but it is cheaper.

14060. (*Mr. Young.*) You gave as the average price of your coal, 11s. 4d. per ton, I think?—That is our present price: that is not at the pit, but that is with the carriage and cost of handling by our own people.

14061. And the cost of stacking and unloading?—Yes.

14062. Is that for the whole of the coal you purchase?—That is the average.

14063. Is it simply for large and small?—Yes.

14064. You give the price of the oil which you are now purchasing at 22s.?—Yes.

14065. Has it fluctuated much in regard to price?—It has gone down very much indeed. I could not buy astatki at one time under 45s. or 50s. per ton.

14066. How long ago was that?—Eight or nine years ago. I had to pay that, except when I bought quantities

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of it in this way: a man would have a tank steamer in the Thames which had run her days and was under demurrage: I would offer him a certain price, say 25s. per ton, and would undertake that at any moment if he could do better I would discontinue taking it; and I bought several times in that way, and on one occasion I bought as much as 2,000 tons at once.

14067. Is it likely, in your opinion, to still fall considerably in price?—I do not know. I should think it will decrease in price as they get larger ships in which the consumption for the purposes of transport—the proportion of the cargo used—would be less for the engines or boilers bringing the oil across, and where the ship's expenses generally would bear a smaller proportion. Then in connection with the Texas oil, I do not think they have such facilities for loading as they probably might have at a later date. All those matters would tend to reduce the price, assuming the quantity to be sufficient to supply every one.

14068. The tendency would therefore be to increase the quantity consumed in this country?—If the price went down, the quantity consumed would increase, undoubtedly.

Mr. James Holden.

29 April 1903.

14069. And it would displace coal to that extent?—Yes.

14070. How will 11s. 4d. per ton compare with the average price over a period of, say, ten years?—I should think it would be rather below the 10 years' average, because there have been one or two very inflated periods during the last 10 years. It is true that there was a depressed period, but the first year of the 10 (1893) was the year of the coal strike, and then there was a great boom in coal; that coal strike cost us some additional £32,000 or £33,000.

14071. I mean by eliminating that?—If you eliminate that, and eliminate the boom price of 1900——

14072. You could not very well do that, because they come practically every 10 or 11 years. If you only take in one boom period with the depressed period, and take that as an average, what, in your opinion, would be the price?—Then I should say that 11s. 4d. would be pretty fairly the average that coal would cost us.

Mr. RICHARD THRELFALL, F.R.S., called; and Examined.

14073. (*Professor Dixon.*) You are a partner now in Messrs. Albright and Wilson?—I am.

14074. And you are a consulting electro-chemical engineer?—Yes.

14075. Will you give us, upon the question of storage of coal and transport, your evidence with reference to any precautions which ought to be taken to prevent spontaneous heating?—Certainly.

14076. We know that you are an authority on that matter?—The position was this, and it occurred while I was in Australia. In New South Wales in about 1895 and 1896 we had an extremely hot summer, and we began to lose ships; there were four ships, I think, burnt within a week, or some period of that kind. It was a thing which had never happened there before, and of course everybody was very frightened.

14077. Were the ships in port?—Either in port or just leaving port.

14078. (*Chairman.*) With Australian coal?—Yes, New South Wales coal. The Government of the day then appointed a Royal Commission, of which I was President, to enquire into the dangers to which ships carrying coal cargoes were liable, and they asked us to suggest a remedy if possible.

14079. (*Professor Dixon.*) Were those ships at Sydney with cargoes of New South Wales coal?—This was at Sydney. We had a Commission, and that Commission reported in 1897, but there were some experiments still left to do, and I got the Commission re-appointed, and it reported in 1900; so that between 1896 and 1900 I was practically continually engaged in the question of spontaneous heating of coal.

14080. Partly in Australia and partly in England?—Yes.

14081. Were your experiments made with both kinds of coal?—The experiments made by the Commission on a large scale were, of course, made with the Newcastle (New South Wales) coal, which was chiefly in question; and the heavy work was done by my colleague, Mr. A. E. Savage. I went into this matter very seriously, and I took the trouble to translate all the papers that I think had appeared in any foreign journal; we had a very good secretary, and we took immense pains over it. In the first report of the Commission, of which I have a copy here, I believe there is an absolute *résumé* of every paper and every scrap of information published on the subject.

14082. Is this an English blue-book?—This is an Australian book, but it is obtainable from the New South Wales Agent General.*

*Report of the Royal Commission appointed on the 28th July 1896 to inquire into the cause of the dangers to which vessels carrying coal are said to be peculiarly liable and as to the best means that can be adopted for removing or lessening the same.

14083. I suppose we can get that, can we not, or perhaps you would put it in?—Yes, I will put it in.

Mr. Richard Threlfall, F.R.S.

29 April 1903.

14084. Perhaps you could give us the results of your inquiry?—I will come to the results immediately. I considered every published report from every Marine Board in the English language (including the American reports) on the cases of losses of ships through spontaneous combustion.

14085. That is to say, ships carrying coal cargoes?—Yes. I believe I have had before me the reports of every enquiry that has been held either in England or in America or in any of the English Colonies on the subject of spontaneous fires at sea.

14086. Will you give us briefly the conclusions?—The conclusion is a very simple one: it is that the cause of heating is the gradual oxidation of the coal by air.

14087. Does that take place more in a confined space than in the open air?—It is a question of temperature. The velocity of the reaction is simply a question of temperature; and whether the coal will heat or not depends upon whether the heat that is generated can get away faster than it is formed. If it cannot get away as fast as it is formed, then you have the coal heating, and the rate at which the oxygen is absorbed also is a matter which depends upon the temperature and goes on much more rapidly as the temperature rises.

14088. But also with the fineness of the coal, does it not?—Well, the coal has to be of a certain kind of fineness; of course, if it is too fine the air does not get into it, and then it does not get a chance of being absorbed; and if it is too coarse, then you do not get the necessary surface for the absorption. As a matter of fact, the heating of a cargo is one of those things which depend upon a very fine balance of conditions. It is a very nice question with regard to any particular cargo as to whether it will heat or not.

14089. Then will you tell us about your experiments with the moisture?—In the experiments with the moisture we—Mr. Savage and I—had two bins of coal, each of them of 245 tons, and these were built side by side under identically the same conditions, the only difference being that alternate barrows of coal were put into the two bins, and a hose was played on the one while the coal was being put in; it was played in gently, so as to not to wash out the dust. The result was that we had one bin of dry coal, and another of wet coal.

14090. Was this Australian coal?—It was Australian coal, from Newcastle. To cut the story short, the dry coal heated up in the regular way until it got to 200° Centigrade, when we stopped it—it was just on the point of firing.

14091. Did you cover it over or not?—No, it was supposed to represent its condition on board ship exactly: the bins each had a roof several feet above the top of the coal. The result was that the temperature

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Mr. Richard Threlfall, F.R.S.

29 April 1903.

rose gradually from, I think, about 40° Centigrade, which was the temperature it started at. That will give you an idea of the weather there.

14092. That is to say it rose from 104° Fahrenheit?—I daresay it is that—40° Centigrade; whereas the coal in the wet bin started at about 30°; the effect of wetting it had been to cool it about 10°; it started at about 30°, and the maximum temperature never got above 47° Centigrade or thereabouts.

14093. (*Professor Dixon.*) What kind of coal was this—the ordinary Newcastle coal?—The ordinary Newcastle coal, which is a very fine house coal of the gassy variety; it is suitable for gas making.

14094. (*Mr. Briggs.*) Was it screened, then?—No, it was not screened.

14095. (*Sir George Armytage.*) What was the average size of the lumps? What sized ring would they go through?—30 per cent. remained on a two-inch mesh sieve, 24 per cent. on the 4-inch, and 24 per cent. on the 8-inch; so that it was the ordinary steam coal. But the point at issue is not the detail as to the size of the coal used. I was anxious to get a coal which I knew could be got to fire; nothing was done to it to make it fire—it was a pure spontaneous combustion; we just left air-holes enough. It did settle once for all the very vexed question as to whether wet coal is or is not more liable to fire than dry coal, because everybody who uses sea carriage for coal believes that wet coal is more dangerous than dry coal, whereas the opposite is the case. In 1876 there was an English Commission on the subject, and the question was put as to whether dry coal or wet coal was the more dangerous, to 27 witnesses; and those 27 witnesses all said that wet coal was the more dangerous. I have asked the question myself, I daresay a dozen times with the same result; I cross-examined my witnesses, but they were not cross-examined by the 1876 Commission. When one came to look into it, it turned out that of those 27 answers 26 were from hearsay only, and there was only one of the witnesses, who came from Nova Scotia, who gave evidence at first hand, and that being a very indirect piece of evidence, it really broke down on examination, and all mine broke down in cross-examination. The result is that there is really no evidence to substantiate it, but it has been an old prejudice, which I believe has arisen from the time when people thought that the heating of coal was something like the heating of hay, and that it depended upon a fermentation process, but it has unfortunately got into the text books, and I need hardly say that has made it almost imperishable. However, in 1900 the Board of Trade asked me to hold an inquiry in order to get information on their records, and I held an inquiry in the case of the "Walter H. Wilson."

14096. (*Mr. Bell.*) Do you refer to the English Board of Trade?—Yes, the Marine Department of the English Board of Trade. This is No. 110 of their circulars.

14097. When was this?—On the 13th June, 1900.

14098. (*Professor Dixon.*) Have you made similar experiments, to those you have described to us, with English coal?—No, I have made no experimetns whatever in England.

14099. From your general knowledge of the similarity of the coal you would say the same thing with regard to English coal?—There is no question about it; it is absolutely certain.

14100. (*Sir George Armytage.*) You do not think it is a matter which appertains to that particular coal?—No, not at all. Fayol, the great French authority who is the manager of the Commentry Collieries, near the Belgian frontier at Pas de Calais, made the same experiments with small heaps of coal 30 years ago, and has come to the same conclusion. It was not scientifically necessary to make the experiment in Australia, but it was morally very necessary to make a little experiment.

14101. Then you would recommend the making of a little experiment with the dust—that is, at the time of putting coal into the ship?—I have recommended that, during the loading of coal, in hot weather at all events, a spray of water should be played down the hatchway, because out of some hundreds of cases which I have investigated, some of them unfortunately personally, there is not a single case in which a fire has started that it has not been just under the hatchway. I thought I had found one case in which that was not so, but curiously enough the master of the ship happened to be in the port of Sydney at the time, and I sent for him and found he had been falsely reported in the report of a Board of Inquiry held at San Francisco.

14102. You attribute the state of things to the dust that has fallen near the hatchway?—Yes, it is the dust chiefly, but there must be just that mixture of coarse coal and fine coal—the fine coal to give the surface, and a little coarse coal with it to give the porosity, or you do not have the proper conditions.

14103. But what I mean is that that is formed as the coal is poured into the hatchway?—Yes.

14104. So that if coal is wetted just at that point it is all right?—Yes, if you wet it just there that would do.

14105. (*Mr. Briggs.*) The air would also get more readily near the hatchway, would it not?—It is battened down; I do not think it would make any difference in that way. The Board of Trade have taken action to some extent in this matter—that is to say, they used to compel captains who had a cargo of coal which was wet, to discharge that cargo, if they got to know of it. They have now, on the strength of these experiments and that work of mine, rescinded that regulation, and they no longer make a man discharge a cargo, but they have not gone so far as to take the next step and make him water the coal if it is very hot.

14106. How often is that watering carried out, do you know, from your personal experience?—It is not carried out at all; nobody does it; I am only anxious to have it introduced.

14107. (*Sir George Armytage.*) Then do you consider that the climate of England is such as to require that watering?—Yes, on a hot day, certainly. There have been enormous numbers of cases of spontaneous combustion in coal coming from England, especially that leaving the Welsh ports. In 1876 I think 4 per cent of the total oversea shipments were heated.

14108. (*Chairman.*) But is there anything more recent than 1876?—Yes; it is not as bad as that now, but I have not the figure in my mind exactly as to the present-day proportion.

14109. (*Professor Dixon.*) But you think the proper precautions are not yet taken.?—Of course the Board of Trade are in this position, that they have to be backed up by the finding of a Commission or something of that sort before they like to act; they were talking at that time of asking for a fresh Commission in order to revise the whole matter, and I feel certain that this Commission, if it cared to do so, could do really great public service in that way by helping them, or at all events advising upon or considering the matter—doing what they could to introduce a system of watering the dry coal under the hatchways. Of course it is a very big subject; there is an enormous amount of work to be done with regard to it; and all I can say is that I feel absolutely certain that if that is done there will be no more spontaneous combustion. It is a question for this Commission to consider whether they are inclined to take the matter up or not.

14110. (*Chairman.*) Are the conditions in the coal-pit the same as in shipping in any respect, would you say?—No The conditions in the gob are somewhat like the conditions in a ship, but speaking roughly and generally they are not similar.

14111. Have you considered at all the question as to whether what is called spontaneous combustion in mines of coal—in the gob if you like—would be obviated by watering?—Well, there is no doubt it would be obviated, but I have not considered the question of the practicability of doing so.

14112. (*Professor Dixon.*) The question would be whether one watering would do it?—No, the coal would probably have to be kept wet.

14113. Your evidence has been that one spraying at the time of charging the coal into the ship is sufficient?—Yes, that is so. I do not say it would be sufficient for ever, but it would be sufficient for a voyage of the average longest duration.

14114. Was there much pyrites in the coal which you investigated at Sydney?—There was about a half per

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cent. of sulphur, as far as I remember, but it has been shown by Fayol that the pyrites has practically nothing to do with it, and I have advanced reasons in the Report to the Board of Trade with which I will not trouble you, showing positively that the pyrites can have nothing effective to do with it.

14115. That is in that particular case?—No, in any case.

14116. (*Chairman.*) Not in the coal pit?—I believe in my own mind that pyrites has never anything to do with the spontaneous heating of coal. It is more difficult to oxidise than fine coal; it gives off less heat, and all experiments which have been made to prove that the facility with which spontaneous combustion occurs has any connection with the presence of pyrites have given a negative result.

14117. Is it not a commonly accepted view that coal containing pyrites is more liable to spontaneous combustion than any other?—Yes; that is the commonly accepted view.

14118. You do not share it?—No, I do not. I feel sure that it has been disproved, and I feel positive that it is erroneous. The extent to which pyrites will heat itself is well known; the question is not whether pyrites can be got to heat, but whether in coal containing pyrites and found to be heated the heating is to be attributed to the coal or to the pyrites; and in that case I feel sure that it is not to be attributed to the pyrites.

14119. (*Professor Dixon.*) You are speaking here from first-hand knowledge?—Yes, I am speaking from first-hand knowledge; and I go further and say that if there is a point which requires further investigation in the matter it is as to the oxidation of different kinds of pyrites. The term "pyrites" itself is not sufficiently precise; there are so many minerals which are physically different which all pass under the name of "pyrites," that it is possible that you would find very great difference in the ease with which they oxidise.

14120. The size of the crystal would come in?—Yes; and very often the lumps of pyrites are of a different nature; some are massive. Of course it is well known to mineralogists that there are different species, and they have different names for these varieties of pyrites. Before I pass away from this subject may I add that my present opinion of this subject is contained in this Report to the Board of Trade? That is the résumé of all our work in Australia.

14121. (*Chairman.*) Will you please hand in that Report —Certainly. I have brought all these papers for the purpose of handing them to the Commission.

14122. (*Mr. Bell.*) You have been holding inquiries in cases of spontaneous combustion since the Commission of which you were President?—Yes. The Board of Trade knew of that, and asked me to hold an inquiry for them, in order that they might get our views on their papers officially. New South Wales is a foreign Government as far as the Board of Trade are concerned.

14123. You made findings in those inquiries similar to those you made in the Commission?—Well, the Board of Trade Inquiry is the last, and I had the advantage of more and more experience all the time.

14124. Has the Board of Trade not taken any notice of this?—Yes, indeed they have. I have said the Board of Trade have altered the regulation as to the obligation to discharge wet cargoes.

14125. Then that is all wrong?—No, they used to make people turn their cargoes of coal out if they got wet by rain for fear they would catch fire.

14126. I beg your pardon, I did not understand you. Have they issued any circulars to coal shippers or collieries owning ships?—Yes, I have produced one of their circulars which I believe has been sent in that form to a large number of the officers. [Board of Trade (Marine Department). No. 110 "Walter H. Wilson."]

14127. (*Mr. Young.*) With regard to the experiments you made in stacking the wet and the dry coal, how long was the coal stacked before the temperature was raised to 200° Cent.?—The dates are January, February, March, and so on. This shows the curves. (*The Witness referred to the Report of the Royal Commission, appointed 11th May, 1897, to make further investigations into the causes of the dangers to which vessels carrying coal are liable.*)

14128. What was the quantity in each stack?—245 tons.

14129. (*Mr. Bell.*) Do you know anything of the kind of precautions taken by ships loading coal for long voyages now and during the last few years?—I am afraid they do not take very many precautions; there is the Lewis and Hunter system of loading, with which no doubt you are acquainted, in which the coal is lowered to the bottom of the hatchway so that it escapes breakage to a certain extent, which is most important.

14130. But as regards ventilation?—No; the Commission in 1876 decided that it was a bad thing to ventilate, and it has never been done since. They have surface ventilation between the back and the top of the cargo, but no ventilating tubes. The ventilating tubes were a frequent cause of spontaneous combustion; they just took enough air in to get the oxidation right, and did not take in enough to cool the coal.

14131. (*Mr. Young.*) Do you know the quantity of water with which that stack was saturated?—Do you mean the percentage of water in the coal in the wet bin?

14132. Yes?—I am afraid I cannot give you the exact figure at the moment; but to the best of my recollection it was about 10 per cent.

14133. (*Mr. Briggs.*) I suppose you do not consider that in voyages of under a week, say, there is the slightest occasion of danger even in hot weather?—No.

14134. You are only speaking of voyages during long periods?—Yes; 90 days, and so forth.

14135. In the other experiment you wetted the coal at the beginning, but you never re-wetted it?—Oh no; we let it go at that.

14136. There is a point which occurred to me that sometimes one lays up coal in heaps on the surface now in England for storage?—Yes.

14137. Which heaps, we know, occasionally spontaneously ignite?—Yes.

14138. Would you consider that if they were wetted when they were put down that would be a safeguard?—Yes, that would, undoubtedly.

14139. I have known it myself not infrequently with all sorts of small coal, but they have been perhaps six or eight months on the ground before they ignite?—That is so. It depends very much upon the depths of the heaps of coal.

14140. Yes; we should restrict the depth now to 6 or 8ft.; formerly we used to put them deeper than that?—Yes, you would be quite safe then, I think; in fact perhaps you might go deeper than that.

14141. With wetting you think we could go deeper?—I think you could go almost indefinitely with wetting.

14142. (*Dr. Le Neve Foster.*) You are of opinion that we as a Commission might do something in the way of making recommendations to the Board of Trade?—It is not for me to say what you should do, but I know that the executive officers of the Board of Trade who have gone into this matter are thoroughly convinced, and they feel exactly as I do about it, but they do not feel inclined to reverse the decision of a Royal Commission without having a Royal Commission to recommend it. That is what it comes to practically.

14143. Would you suggest that we should make any further experiments on the subject?—No, I would not make any suggestion at all, except that if you could consider this matter, or if any of your members could consider it so as to pass an opinion upon the problem of wetting the coal, that could be communicated to the Board of Trade, I think it would be a help to those officials who would like to encourage the wetting of coal, and who yet feel themselves not sufficiently strong to do so in the face of the opposite finding of the Royal Commission of 1876. The Royal Commission of 1876 did report that wet coal was more dangerous than dry coal, which was in accordance with the evidence, but their two scientific experts, Professor Abel and Professor Percy, who made a scientific report for them, thought the wet coal would be safer than the dry coal. In spite of that the Commission, I presume, thought they ought

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Mr. Richard Threlfall, F.R.S.

29 April 1903.

to go by the weight of the evidence rather than its quality, and they found against their own experts.

14144. Sir Frederick Abel and Dr. Percy made a minority report?—No, they did not; they were not asked to do so; they were asked to send in a report on the scientific aspect, which was published with the main report, and in that report, although they had not made any experiments, they came to the conclusion that wet coal must be safer than dry coal.

14145. (*Sir George Armytage.*) Then you are of opinion that if similar experiments were made in a similar way to what you have made in Australia, you would practically arrive at the same results with regard to the English coal?—I am perfectly certain, because so many experiments have been made by other people with different sorts of spontaneously igniting coal, that we know there is not one sort of coal that heats in one way and another that heats in another; they all heat in the same way.

14146. Do you think that that would be the case irrespective of the quality of the coal?—No; the bituminous coal heats more in any case, but supposing you are given a coal which is apt to heat, then our experiment would apply to it, whether it be English, Australian, or Belgian coal.

14147. (*Mr. Bell.*) Do you think this simple fact has come to the knowledge of the coal shippers and the colliery proprietors of the Kingdom?—I do not know. You know how difficult it is to get these matters put forward; I have not taken any steps. The Board of Trade have sent out circulars, and that is all they have done, so far as I know, except that they have released people from the obligation of discharging wet coal.

14148. (*Chairman.*) The trade at different ports has been largely interfered with by the number of explosions which took place years ago, and which I always understood were never properly explained?—That I cannot say, except that you might have an explosion quite independently of spontaneous combustion. If you took a hard coal which was saturated with gas which might be perfectly cold, and from which the gas might yet be given off, then you would have an explosion, which would be a different matter; but it does very often happen that, when coal is spontaneously heating, the hot coal does distil off gas from the colder coal around it, and that gas accumulates so that explosions of gas very often accompany spontaneous heating; but you may have explosions of gas where there is no spontaneous heating at all.

14149. (*Professor Dixon.*) We will pass on to another matter; you have had very considerable experience in the manufacture and use of producer gas?—I have.

14150. Could you give the Commission your experience as to the economy generally to be obtained by the use of producer gas in connection with gas engines instead of using coal for steam raising?—Yes, in general terms. I think there is no doubt that you can get a given amount of power more economically, as far as coal is concerned, by using gas engines than by using steam engines.

14151. You are speaking now from your personal experience?—Yes, certainly—a very large personal experience.

14152. (*Chairman.*) Could you say whether it would be half the price?—No, I could not; it depends entirely upon conditions. I would not say half the price, but I would say less than half the quantity of coal, in many cases.

14153. But that is a distinction without a difference is it not?—No, indeed, because the cost of the power is made up of a large number of factors besides the factor of coal.

(*Chairman.*) But then you were speaking of coal.

14154. (*Professor Dixon.*) We were speaking of coal at first. You mean with regard to the cost price of the initial installation?—Yes. I am afraid, perhaps, I made a mistake. I did not understand the question, perhaps it might be economical to use a steam engine, even if it took twice as much coal.

14155. Then, under ordinary conditions, such as obtain in the manufacturing districts in England, very considerable economy is to be expected, according to your experience, from the use of producer gas and gas engines. The Commission can take that as your experience, can they not?—Economy of money or economy of coal?

14156. I mean economy of money here?—I am not prepared to speak about economy of money without going into details; but I can say definitely as to the economy of fuel. The replacement of a steam engine by a gas engine leads to a large economy of coal; whether it leads to economy of money is a matter depending on the size of the plant, and so on.

14157. Can you give the Commission any evidence upon that point from your experience?—Do you mean with regard to the relative cost of raising power?

14158. Yes, the relative cost of power, using coal in the two different ways—of course, assuming that you are in a manufacturing coal district?—Well, I think you might certainly say that the cost of a unit of electricity (which is how we always reckon) would certainly be less than the ratio of 2 to 3 if raised by gas, as compared with raising it by steam, and probably a good deal more.

14159. The coal being the same in each case?—Yes, but there, again, there is a difficulty; rarely in a given district would you use the same coal under a boiler that you would use in a gas producer.

14160. No, I am speaking generally.—In nearly all coal districts there is coal of different sizes to be had. Perhaps very often you could burn under your boilers coal, shall I say, at 6s. per ton, whereas you might have to pay 8s. per ton for the coal for the producers.

14161. Speaking from your experience under the most favourable conditions, what price do you put the electric horse-power at?—By steam?

14162. Well, by steam, or by using the gas?—In what size plant?

14163. Say 5,000 h.p.?—I do not know that I have any actual experience of quite 5,000 h.p.

14164. I am only giving that as an illustration?—Of course it depends so much on the size of the plant.

14165. Say 10,000 h.p.?—There is an estimate made by Mr. Humphrey, the author of a paper read before the Institution of Mechanical Engineers in December, 1900, as to what it would cost for 10,000 h.p.

14166. Is that for steam?—Both for steam and for gas.

14167. I will ask you from your own experience, what would you put the price under good conditions with a large installation, say of 10,000 h.p.; what price would you put the electric h.p. at, using gas engines, and the conditions being favourable?—I should say it would be under ·2d.

14168. And the steam would be ·3d., I suppose?—It may be got down below ·3d.—I should think ·25d., or something of that sort. That would include ordinary works cost; it would not include depreciation, fixed charges, rates and taxes, or interest.

14169. (*Chairman.*) Wages and material?—Yes—net works cost.

14170. And repairs?—And repairs, of course.

14171. (*Professor Dixon.*) How does that compare with the practice where water power is available?—Well, the Niagara power, which is a 20-dols. power, runs out to ·155d. or thereabouts.

14172. Twenty dollars makes about ·155d. does it not?—Fifteen-hundredths of a penny. They are talking now of 10-dols. power, which would mean, of course, half that.

14173. Are they speaking at Niagara of 10-dols. power?—Yes. The people who are selling at 20 dols. are now speaking of 10 dols.

14174. So that at present in your experience there is a good margin of balance on the side of the water power as given, for instance, at Niagara?—Yes; I think Niagara is very dear for water power. I know of places where it is certainly not more than a quarter of the Niagara price, that is to say, 5 dols.

14175. Is that because the machinery is less costly?—I could not say. I think it is possible to find conditions in which a small power could be obtained with less relative capital cost than was necessary at Niagara. At some places in Canada, and in the French Alps—certainly in

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the French Alps—I have very good reason to believe the electric power is only costing 20 francs per electrical horse-power a year; that is equivalent to about a 5-dols. power.

14176. It is under 5 dols.: it is about 4 dols.—Well, we will say 5 dols.

14177. Are they actually selling power at that rate?—No. There is a particular firm which makes its own power, and an eminent Swiss engineer, who is an intimate friend of mine, gave me the reason why they could not possibly be paying more than 20 francs, and I went into it, too, and I did not think they were paying more than 20 francs. Of course that is exceptionally favourable.

14178. Speaking from your experience, is there any reason why electrical works, especially for electro-chemical work, should not be run to advantage in this country?—No, not in the least, if we can get the power down to a reasonable figure. Fortunately these people in Switzerland and elsewhere, who get cheap power, are very heavily taxed by the railway in many cases—what the Americans call "well-soaked"—and the advantage of the cheap power very soon goes away if they have very heavy railway rates.

14179. So that in your experience we ought to be competing in England, say, in an electro-chemical works?—Well, I discriminate a little. I think there are some things that must go to water power where the expense is nearly all on the power, such as chlorate making or carbide making, where the cost is almost all on the power; but I think in matters for which a moderate amount of power is used, we can compete.

14180. Will alkali-making go to America, do you think?—You mean will it go to water power. No, I do not think so; I think there are railway rates that would hold it near the market.

14181. That would be the determining factor, no doubt?—Yes, I think so—but I am not an alkali-maker.

14182. But you are a chlorate maker?—Yes.

14183. In your opinion alkali would be made where the power is cheap?—It would be made where the power is cheap.

14184. Would you give us the benefit of your experience with regard to the transmission of power. We have had evidence concerning the transmission of producer gas of various kinds, and the transmission of electric power; have you any experience as to the relative advantages of those two?—I have never been engineer for a big transmission scheme, or rather I was once many years ago, but it came to grief.

14185. I am speaking not of very great distances, but of such distances as we might have in the manufacturing districts in the Midlands?—Yes. I think they are both perfectly feasible and practical means for distributing power; it is only a question of the customers.

14186. Is there a demand now for producer gas to be sent from a central station?—I think in many places there is a demand for it for furnace purposes. You see gas is a very handy thing; you can use it for more things than you can use electricity.

14187. But I suppose only small works would demand it, would they?—It would be made if there was a big demand?—Yes; it would depend, of course, what price they were charged for gas, but if they were charged anything like 1d. to 1½d. per 1,000 cubic feet, I do not think it would pay to make it, unless the manufacturers were making gas equivalent to something like 20 tons of coal per day.

14188. (*Chairman.*) But the real point is whether at a central station you could make it so much cheaper in bulk that you could afford to bear the expense of transmitting it, say, 25 miles, and still sell it to the customer at the point of distribution at less cost than he could make it for?—I know of my own personal experience how enormously the cost of gas-making with ammonia recovery goes down with increase of output. I do not think it pays to recover ammonia, unless you are burning something like 75 tons of coal per day anywhere. But if you can get up to something like 300 tons or 400 tons of coal per day, your labour at the producers, which is the chief item in the ammonia-recovery process, goes down; and I should be quite prepared to believe it would pay to carry the gas 25 miles or 30 miles. I do not wish to give evidence about that, because I have not calculated the cost of transmission—it is a matter I have not gone into.

14189. (*Professor Dixon.*) You are making Mond gas yourself?—Yes.

14190. And recovering ammonia?—That is so—next to Mond I believe more than anybody.

14191. Are you keeping a separate account of the cost of the Mond production?—Yes—every item.

14192. So that you can compare that with other methods?—Yes. We have made enormous quantities of Wilson gas, which is practically the same thing; all producer gas is the same, only people put their names to it.

14193. I suppose you are running more steam now into the Mond?—It is generally popularly supposed that it takes more steam, but I do not think there is anything in that. The other people who claim not to use much steam I do not think measure what they are using. When we measured the steam about a couple of years ago I know it was an astounding amount; it was nearly as much as the Mond was taking.

14194. Then your view is that producer gas, however made, is all one?—It is, practically.

14195. It is a mere question of separating the ammonia?—It is a matter of thermal value. These producers have what is known as a coal gas efficiency of 75 per cent. to 80 per cent., which after all must simply mean the heat in the coal passed through the system per hour, less what is lost by radiation. That is the only loss in the producer, if you look at the thing as a whole. The losses in thermal energy are those lost by radiation and conduction. If you look at producer plants they are all very much alike, and their radiation and conduction losses are all very much alike; therefore they must all have about the same efficiency. The composition of the gas may vary, but the thermal units obtained in the shape of gas per ton of coal must be pretty constant. Experience shows that that is so.

14196. Originally coke was used, was it not, and now coal is used?—But that does not make any difference to the constitution of the gas.

14197. Surely it makes a difference in the constitution of the gas, not to the loss or gain, of course, but in the constitution of gas?—What difference can it make?

14198. You get marsh gas when you are using coal?—Well, I wish we did; if we get 1·4 per cent. we think we do very well.

14199. Well, you get up to 2 per cent., I suppose?—I have never seen it; you always read of it and hear of it, but I have never seen it. You read of it up to 4 per cent.

14200. I have found it up to 2 per cent.—May I suggest that perhaps the plant was not working quite continuously when you found it up to 2 per cent.

14201. Possibly.—If you let the plant stand, you can get fine gas. If you let it stand for half an hour and then take the first that comes off, you get splendid strong gas; therefore it is very important that one should be always careful to know how the producer has been working before the test is made. But I will admit you might get up to 2 per cent. on occasion.

14202. Of course it varies with the feed of coal. It must do so?—Yes. The general run of gas is less than 2 per cent.

14203. Have you experience of the transmission of electric power?—Certainly.

14204. Then you can give us your view. Have you any opinion to express to the Commission upon the comparison between distribution of power by electricity and by producer gas. Do you consider those are competing forms?—I think it depends so much on the customers; as I was saying before, if you can get your customer to take gas, you could perhaps sell gas when you could not sell electricity.

14205. As being more applicable to a number of things?—Quite so; there are many purposes for which gas would be used direct. You see you have two strings to your bow if you have gas; you can either use it direct as fuel, or you can turn it into power, but you cannot transmit

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Mr. Richard Threlfall, F.R.S.

29 April 1903.

electricity and use it as fuel except under very exceptional circumstances.

14206. You mean except in an electrical furnace?—Not then, except under exceptional circumstances, because you must generally have it at the lowest possible price to be able to do any good with it, if you use it in an electrical furnace.

14207. And you might have to transform it down?—Yes, but that would not help you. The cost of transmission of electricity would be too high, or would tend to be too high.

14208. That is to say, the original cost?—The original cost. I am not talking now of a place like Niagara Falls, where they actually make the electricity in the power-house at a very low price, so that they are able to transmit it, and sell it transmitted at a low price.

Mr. VIVIAN BYAM LEWES, called; and Examined.

Mr. Vivian Byam Lewes.

29 April 1903.

14209. (*Chairman.*) You are Professor of Chemistry at the Royal Naval College, Greenwich, are you not?—I am.

14210. And Chief Superintending Gas Examiner to the Corporation of the City of London?—Yes.

Summary of Evidence.

(1). Owing to the introduction of the incandescent gas mantle the tendency of the present day is towards a reduction in the illuminating power of coal gas, and the poorer quality of gas demanded will probably be arrived at by diluting coal gas, as ordinarily made by the carbonisation of gas coal, with either carburetted or blue water gas. Experiments in this direction have already gone so far as to give reliable data as to what may be expected from it in the economy of coal.

(2). Even should the present tendency towards reducing illuminating value not continue, carburetted water gas as an auxiliary to coal gas will in the future play an important part, and tend to lessen the weight of coal annually carbonised.

(3). In the United Kingdom approximately 15 million tons of coal were carbonised last year for the production of coal gas, yielding an average of 10,000 cubic feet of gas per ton. To this, however, must be added the carburetted water gas and blue water gas used in admixture with the coal gas in many large towns, which brings the total make up to 165,563,885,000 cubic feet.

In London alone the three big Companies carbonised about 3,250,000 tons, the Gas Light and Coke Co. using 1,800,000, the South Metropolitan 1,183,000, and the Commercial 203,000 tons.

(4). An idea of the economy in the weight of coal used, when a mixture of coal gas and carburetted water gas is distributed in place of pure coal gas, may be obtained from the working of the Gas Light and Coke Co., which uses carburetted water gas as an enricher, and the South Metropolitan Co., which sends out coal gas only.

In the year ending June 30th, 1902, the South Metropolitan Gas Co. carbonised 1,183,101 tons of coal, and made 11,976,041,000 cubic feet of gas, or 10,123 cubic feet per ton, whilst the Gas Light and Coke Co. carbonised 1,829,699 tons of coal, and made 22,571,273,000 cubic feet of gas, 4,079,499,000 of which was carburetted water gas, amounting together to 12,336 cubic feet per ton of coal as against 10,106 cubic feet of coal gas made per ton from coal alone.

From this it will be seen that the gas yield per ton was practically identical for the two Companies, but that the Gas Light and Coke Co., by making 18 per cent. of their gas from coke steam and oil, were able to use 403,652 tons less coal than they otherwise would have had to do to get the same volume.

This makes no economy in cost as the carburetted water gas costs a little more than the coal gas, but it enriches the candle power of the gas and saves 22 per cent. on the coal used.

About 40 lbs. of coke being used in the generator, and 15 lbs. of breeze it is evident that the amount of saleable coke will be reduced.

(5) The limit of quantity of carburetted water gas which can be added to the coal gas is arrived at from the percentage of carbon monoxide in the mixed gas, which in my opinion, should not exceed 16 per cent. on account of its poisonous properties. From the recommendations of the Committee which lately considered the question of water gas it seems probable that this will be about the legalised limit, and this would enable 48 per cent. of carburetted water gas to be added to the coal gas, which would make the saving in coal much more marked.

(6) Should, however, the present tendency to lower the illuminating power continue, then undoubtedly the most economical method of making low power illuminating gas, is to pass blue water gas through the retorts during the carbonisation of the coal. The blue water gas containing 38 per cent of carbon monoxide, as against 28 per cent. in carburetted water gas, would limit the admixture to about 34 per cent. If such a process were universally adopted throughout the Kingdom, the total economy in gas coal would approximately amount to about four million tons annually.

(7) For lighting purposes several oil processes have been introduced during the last few years which give by means of the incandescent mantle light at a cheaper rate than even coal gas, so that it is possible to obtain a light of 1,000 candles per hour at the cost of a penny, which is nearly three farthings a thousand cheaper than could be obtained from coal gas.

14211. You say that owing to the introduction of the incandescent gas mantle, the tendency of the present day is towards a reduction in the illuminating power of the coal gas supplied to the public?—Undoubtedly: the whole tendency has been, during the last five years, towards a reduction in candle power. Up to that time, we had had constantly a cry for higher and higher illuminating power in the gas, but when, in 1892 and 1893, the mantle was becoming commercially successful, it was at once realised that it was not necessary to supply so high a candle power, and that therefore some of the cost of making the gas might be saved by doing away with the enrichment which, up to that period, had been necessary.

14212. Does that lead to economy in gas bills?—Undoubtedly it does. Enrichment in every form is expensive. Up to 1889, the enrichment of coal gas was entirely dependent upon cannel, and the price of cannel went up to such an extent, that the enrichment cost very nearly 2d. per candle. Then cheaper methods of enrichment were looked for, and were found in mixing the coal gas with what was known as carburetted water gas—the gas made from water gas mixed with oil gas—and also another method of enrichment was adopted of passing the gas through light mineral oils, like benzol and petroleum spirit. These methods were distinctly cheaper than the cannel coal enrichment had been, and probably the cost does not now exceed a ½d. to ¾d. per candle.

14213. Have you fixed in your mind any minimum point of illuminating power?—My own impression is that the useful minimum one could go to would be 12 candle power.

14214. And that with the aid of a mantle, you could get perfect combustion and illumination?—Yes, perfect. The whole theory of the incandescent mantle has been very little understood; one has always thought that the light which is got from the incandescent mantle is almost entirely dependent upon the calorific value of the gas. I have been making a very large number of experiments lately, and I find to my great astonishment that you have got other factors distinctly at work, and that with the reductions in illuminating power, you do not get at all a corresponding reduction in the light which your mantle emits, within very wide limits indeed. Very often where you have an enriched coal gas, with fairly high calorific value, your mantle will give an absolutely worse result than when you are using a poor coal gas, say of 12 candles; and in fact, even with blue water gas you

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can get results which are very nearly as good as with coal gas.

14215. (*Professor Dixon.*) Burnt in the same quantity?—Not burnt in the same quantity, but per cubic foot. There was a series of papers read by some American investigators published a little while ago, by White, Russell, and Travers, in which they proved to their own satisfaction, by a most elaborate series of researches, that you had the candle power of the mantle directly related to the calorific value of the gas, and that there was a considerable fall. They found that water gas gave 5 candles per cubic foot. With many ordinary burners that you can get in Germany at the present moment, you can get 15 candles per cubic foot with water gas; and with one burner, a little more carefully made than the rest, I have got as high as 19 candles with blue water gas; water gas has a calorific power of 320 British thermal units, whereas, 16 candle coal gas with which you get no greater illuminating power has a calorific value of 640 British thermal units, and the fact that you have an incandescent mantle giving so little variation in the lighting power shows that this change in the quality of the coal gas is not a very important factor in tending to the lowering of the candle power with the mantle.

14216. (*Chairman.*) Does the cost fall in relation to the high candle power?—No, it does not. In calculating the cost on the coal gas you have to take first of all the whole body of gas which is non-luminous; you have the illuminating value of the gas depending only upon some 4 per cent. of it, whilst the really expensive and the really best portion of the coal gas is the methane or marsh gas which it contains. So that you might take the whole body of gas, which would give you something about 8d. per 1,000 cubic feet, and then the candle power is an increment upon that; I mean to say, many people argue that if you get a 16-candle coal gas at 16d. (of course you do not, but supposing you did), they then might take a 1d. off for each candle power that they get, which would mean that they then got the heating body of the coal gas for nothing.

14217. But of course you would sell 12-candle power gas at a less cost per 1,000 cubic feet than you would 16-candle power gas?—Exactly.

14218. Therefore the saving which is effected by the mantle is not the whole of the difference?—No, the saving effected by the mantle is not the whole of the difference.

14219. Is there much difference between the cost of the gas you have referred to and the cost of coal gas for producing the results which you have described?—Do you mean as regards the mantle?

14220. You spoke of the water gas, did you not?—Yes.

14221. Let me see if I understood it rightly; I understood you to say (and I thought that was rather new) that with the mantle you could get from water gas as much illuminating power as you got out of the coal gas?—Yes, very nearly.

14222. Would the gas cost the same?—No; blue water gas in the holder made by the Dellwik process would cost you perhaps only 5d. per 1,000 cubic feet.

14223. As compared with, we will say, 8d.?—As compared with 1s. 1d.

14224. As compared with 1s. 1d. in the holder?—Yes.

14225. And then there is some fault attaching to it or some difficulty, is there?—The difficulty, of course, with that would be the poisonous properties of the gas.

14226. Is it used in conjunction with coal gas?—It is used largely now in conjunction with coal gas.

14227. Do you call it adulteration, or enrichment, or admixture?—You generally call it nothing; you simply send it out.

14228. You do not even call attention to it, I suppose?—No. I mean to say for the last 10 years the population of London, north of the Thames, has been supplied with gas containing 22 to 25 per cent of what is termed carburetted water gas.

14229. Then I may take it that for the same quantity of light or illuminating power, we may look upon the incandescent mantle as being a great coal saver?—Undoubtedly; not only in regard to the enormously increased light which you get from a foot of gas, but also in the general tendency which that has on saving gas.

14230. The general tendency is to use more light, is it not?—Yes, the whole tendency of the present day is to get to higher and higher lights; and a very bad tendency it is too.

14231. (*Mr. Bell.*) What would be the result in a room; the tendency being to have more light, if you substituted the mantles and reduced the number of burners, what would be the saving in the consumption of gas, allowing for the fact that people will have more light?—Well, if you take the old flat flame gas burners, such as used to be universal in our sitting-rooms, you would find that there you were burning coal gas and that you were not getting much more than one candle or from one to two candles per cubic foot of gas consumed; you now use the incandescent mantle and you get practically 17 to 20 candles per cubic foot of gas consumed by using the mantle; that is, you get that enormous increase of light, so that even with a very large increase in light one mantle now will do the work for which you used to require at the minimum three or four flat flame burners.

14232. (*Chairman.*) Then you think that great economy can be effected in the weight of coal used for the purpose of making gas by the mixture of coal and carburetted water gas?—Undoubtedly there is an economy in the amount of coal used, although there is not very much economy in cost.

14233. There is some question about coke, is there not?—Yes; but the question is not that; it is in regard to the price of the oil. You see you must keep perfectly clear in your mind the difference between carburetted water gas, which is now largely used, for instance, by the Gas Light and Coke Company for mixing with their coal gas, and blue water gas. Blue water gas is simply made by passing steam over coke; carburetted water gas is made by passing steam over coke and then taking the hot gas through heated chambers in which oil is being cracked or converted into oil gas; so that you get a mixture of the oil gas and the water gas, non-luminous water gas being rendered luminous by the mixture with the oil gas.

14234. With regard to the economies to be effected by the use of that, you compare the Gas Light and Coke Company and the South Metropolitan Company, and you say that the gas yield was practically identical for the two companies, but that the Gas Light and Coke Company, making 18 per cent. of their gas from coke, steam and oil, were able to use 403,652 tons less coal than they would otherwise have had to do to get the same volume. But they would have less coke to sell as a bye-product?—They would have less coke to sell as a bye-product, but the difference is so small that it makes very little difference indeed on the returnable amount of coal. Of course, figures of that character can only be got from the yearly returns of the gas companies. Now the South Metropolitan Gas Company make no water gas, and they sell 11 cwt. of coke per ton of coal carbonised, whereas the Gas Light and Coke Company, which does make water gas, sells, I think it is, 10·8 cwt. per ton of coal carbonised. So that you may take it that the difference in the sale is a very small one.

14235. But the South Metropolitan Gas Company sell a lower candle power gas, do they not?—They sell a lower candle power gas, but that lower candle power is not due to differences in the coal and differences in the carbonisation, but due to the fact that they have not enriched it by mixing in with it this carburetted water gas which has a higher candle power than the coal gas itself.

14236. Is there a limit to the quantity of carburetted water gas which can be added to the coal gas?—Yes; that limit is made by the percentage of carbon monoxide in it. Of course, in America, the gas companies have a perfectly free hand, and a large proportion of them send out simply carburetted water gas. In parts of Liverpool we had also plain carburetted water gas sent out with no admixture at all; but the feeling against that has been very strong, and I think that the general tendency, and a point which will probably be reached by legislation, is to cut down the percentage of carbon monoxide in any gas sent out for domestic use to about 16 per cent. That

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Mr. Vivian Byam Lewes.
29 April 1903.

is the limit which I myself fixed upon and gave evidence upon as being the safe limit, and one which I do not think ought to be exceeded. That would bring down the percentage of carburetted water gas, which you could add, to a little under 50 per cent.

14237. Do you think that would make it practically safe?—That would be very practically safe; it would only be then in the cases of very big leakages that you would be likely to have fatal accidents.

14238. Then you think if the present tendency to lower the illuminating power is continued, the most economical method of making a low power gas would be to pass blue water gas through the retorts during carbonisation?—Through the carbonising retorts while the carbonisation of the coal is going on. I have made a number of experiments in that direction, and there is not the least doubt that if you do that, the big volume of coal gas passing through the retort whilst the gas is distilling at a high temperature prevents decomposition of many of the valuable hydrocarbons. In an ordinary coal-gas retort where the gas strikes the overheated crown of the retort, some of the gas is decomposed, and you get a large deposit of carbon on the crown of the retort, that being due to the breaking up and decomposition of some of the hydrocarbons in the gas which are most useful for illuminating purposes.

14239. You say that if such a process were adopted throughout the United Kingdom the total economy in gas coal would, approximately, amount to about 4,000,000 tons annually?—If, taking last year's carbonisation you had had such a process as that made universal, it would have made a saving of about that quantity.

14240. Would that mean that there was less coke available for sale?—No; of course you have to make your water gas first of all, and in the manufacture of blue water gas by the Dellwik process, which is now very largely used, you can make 66,000 cubic feet of water gas per ton of ordinary gas coke.

14241. Have oil processes been introduced during the past few years which give light by means of the incandescent mantle, at a cheaper rate than coal gas?—Yes, there have been several processes introduced for burning oil, vapour, and air in atmospheric burners, and using those for incandescing the mantle.

14242. Is that the kind of thing that is known as the "Kitson" light?—One process is the Kitson light; that is a hot process in which you vaporise your oil in a little superheating tube above the mantle; and there are also plenty of cold processes in which, by passing air over petrol spirit, you cause it to take up a certain amount of that spirit and then burn it in an atmospheric burner.

14243. But petrol spirit is rather a dangerous thing, is it not?—Very dangerous.

14244. Do you lean at all in the point of safety to one or the other of them?—I think both of them are made safe by proper handling and proper precautions.

14245. Is there much risk about the Kitson light?—No.

14246. That is only done under pressure, is it not?—That is done under pressure; the oil is sprayed into the little vaporising tube by air pressure in the oil receiver.

14247. What is the price at which a light by those processes can be obtained?—By the Kitson light and also by a new cold process, which is not yet on the market, you can get 1,000 candles per hour for 1d.

14248. Do you think that the use of oil will make progress for illuminating purposes?—Yes.

14249. It is not available for anything except those big lights, is it?—No. It will not cut seriously into the coal gas.

14250. It may be used for street lighting?—Yes, the Kitson system is very convenient for that purpose.

14251. And for docks?—It is excellent for docks.

14252. It is cheaper than electricity?—Yes, undoubtedly, far and away cheaper, and it is even cheaper than coal gas.

14253. Do you think that electric light has a serious competitor in it?—I think so.

14254. It is cheaper taking into account the cost of the oil?—It is considerably cheaper taking into account the cost of the oil, and it does not mean the breaking up of roads; that is to say that each installation is self-contained.

14255. Each is self-contained or may be. Have you any experience with regard to the flash point of these oils?—Yes.

14256. There is a considerable variation in them, is there not?—Yes.

14257. Have you any views as to what the flash point of safety is?—I think there is no fault to be found with the present flash point. If you go to higher flash points you get into other troubles.

14258. Would you put it at 150°?—The flash point for lamps is 73°. If you go into higher flash points, and if you have a flash point of 100°, you would get a greater heating of the oil vessel, and you would have a greater degree of danger coming in in that way. I quite agree with the evidence which Dr. Redwood gave on that point.

Would you put a question to me, sir, with regard to spontaneous combustion of coal? I heard the evidence of the last witness, and as I have had a good deal of experience, and have done a good deal of work on spontaneous combustion of coal, there is one point which I should very much like to mention.

14259. Is your experience of coal on board ship or on land?—The cases of spontaneous combustion that I have known, and which I have personally seen from the very first, have been cases upon land, but I have inspected many ships in which there has been spontaneous combustion—before the whole of the cargo was taken entirely away and simply the heated pockets had been taken out.

14260. (Mr. *Bell.*) After the explosion?—After the combustion. The point I should like to bring forward is this: you have heard Professor Threlfall's evidence as to the efficiency of wetting coal, and the strong way in which he advocates wetting coal. I have known several cases, and I believe there is ample evidence in many cases in which there have been ships loaded throughout with the same kind of coal which they have loaded at the fore hatch in fine weather, and when they have been loading at the after hatch and rain has come on, invariably I think evidence will show that where they have had that moistening of the coal—not wetting of the coal, but moistening of the coal—they have had the heating taking place at that point. Now, rule-of-thumb and common prejudice is no evidence, but still you very rarely find a factor get so thoroughly fixed in all experts' minds as that damp coal is more dangerous than dry coal without there being some foundation for it. I think the weak point in Professor Threlfall's evidence is this: he has given you the experiment in which he took one bin of 240 tons of dry coal and another bin of 240 tons upon which, according to his evidence, a hose was played while it was being put in, that is to say, that the coal was thoroughly soaked.

14261. That is 10 per cent. of water?—Yes, 24 tons of water in 240 tons of coal. All the time that you have that water there, and have that coal thoroughly wet you have the pores of the coal closed by the water, and you have the heat of the atmosphere causing the evaporation of the water and rendering an enormous amount of heat latent, and naturally keeping the temperature of the coal down. That experiment went on, as I understand, for about a couple of months. But if you had that coal then dried down to a point when you had a mere moistening of the coal, and not a wetting which closed the pores, which would render the heat latent, what would then be the effect? Would he find that he had stopped spontaneous ignition when he got to that point? Of course, the owner of a coal vessel could not afford to increase the weight of his coal carriage by keeping 10 per cent. of water awash in the bunkers, and I must say I look upon the suggestion of wetting coal with a good deal of doubt. With regard to the part played by pyrites in coal, there is not the slightest doubt that Professor Threlfall is right, and for this reason, that when we inspect a case of spontaneous combustion where coal is heated, sulphur comes off as sulphuretted hydrogen, and not as sulphur dioxide, as would be the case if pyrites had anything to do with it.

14262. (*Chairman.*) Have you had occasion to investigate any cases of spontaneous combustion? I thought you spoke rather of explosions, or somebody used the word "explosion"?—No, spontaneous combustion.

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14263. You draw a distinction between the two, do you not?—Yes, a very great distinction; it is an entirely different thing. Explosion occurs by the mixing of gas from the coal with air, which gives you an explosive mixture; that may be ignited by any source of heat; the gas from the coal mixes with the air and gives you what is called fire-damp, and that explodes when heated by any cause to its ignition point. Spontaneous combustion, on the other hand, arises from the generation of heat in the coal which is not able to get away, and it accumulates until the ignition point is reached.

14264. With regard to the question of dry and wet coal, you adhere to the popular prejudice?—Yes, but I should like to differentiate between "wet" and "moist." A slightly damp coal, which is the coal you have to deal with in practice, is far more dangerous than dry coal, in my opinion. With a wet coal, where you have enough water to keep the surface in a non-absorbent condition, and you give plenty of water to be evaporated, and so render the heat latent, that, of course, gives safety.

14265. (*Professor Dixon.*) You have made a good many experiments with regard to the light given by mantles, I think?—Yes.

14266. The light, I suppose, depends upon the temperature of the surface of the mantle?—That is so; but how that temperature is arrived at is at present a very debatable question.

14267. I mean apart from the general character of the flame?—Yes, that is so, but in all probability the action on the surface of the mantle is due to the innumerable extremely minute points of ceria which are spread over the non-conducting surface of the thoria, just giving you innumerable points of very high intensity there.

14268. I am leaving out now the question of any internal chemical action in the mantle; it is very possible there may be some or there may not, but I am leaving that out; the light depends upon the temperature of the surface?—The light depends upon the temperature of the points on the surface of the mantle.

14269. And that, I suppose, will depend upon the intensity and combustion on the surface?—Yes, on the points of the surface.

14270. Yes, actually at the surface?—Yes.

14271. Therefore the gas which burnt more quickly, although it had a lower total calorific value, might give more light with an incandescent mantle?—It might give more light with an incandescent mantle. It is a question of intensity, and not of total calorific value.

14272. It is rather the rapidity of combustion I am suggesting to you?—Yes, that is intensity: it is intensity rather than quantity of heat. It has been over and over again said that it was impossible to use Mond gas or producer gas with a mantle. There is a man who has a burner now which I have seen this morning, giving, I should say, quite 70 candles from a mantle with ordinary Dowson gas.

14273. And fed with air in the ordinary way?—Fed with air in a slightly different way. The burners have a slight difference, but air is fed into it.

14274. Driven in?—Driven in—well, he was working with pressures of 2½in. of the Dowson gas, and that was drawing air in through a perforated plate at the bottom of the burner, and he was burning there 20ft. of the Dowson gas, and he got about 75 to 80 candles; that is to say, he was burning 20ft. of Dowson gas to get the result that he could have got with 4ft. of coal gas.

14275. You said just now that blue water gas would burn in a mantle just the same as ordinary gas?—Yes, and give an excellent result, only you burn it there with no extra air supply; you burn it in an ordinary Argand burner.

14276. Have burners now been used which will burn equally well with ordinary coal gas and with water gas?—No, they are not made.

14277. You would have to have a special burner for it in that case?—Yes.

14278. When you speak of adding up to 48 per cent. or 50 per cent. of water gas?—That is carburetted water gas.

14279. Would not that necessitate some alteration in the mantle or the burner in order to get the maximum result?—No, the burner that burns coal gas would burn that perfectly well.

14280. Up to 50 per cent.?—Yes.

14281. That is the result of your experiments?—Yes.

14282. I think you have had a good deal of experience in testing the illuminating power of gas after it has travelled some distance?—Yes.

14283. Will you tell us your experience there?—My experience is that it will lose about a candle in five miles; it would lose very nearly that.

14284. What kind of mains are you speaking of?—I am speaking of mains which have been in use for some time. If you take absolutely new and clean mains you will find that the loss is very small indeed; but where you get old foul mains, in which you have a quantity of tarry matter deposited on the surface all along, you see that scrubs the gas, as it were, and takes out from it some of the benzine vapour on which a large proportion of the luminosity of the gas depends, and in doing that you get a loss of illuminating value.

14285. Have you any actual experience of the loss of illuminating power coupled with the amount of liquid obtained in the mains taken from the syphons?—No, I have very often tried to get that, but never satisfactorily, simply because the liquid which they pump from the syphons is so volatile—the benzines and things of that kind—so that by the time you get the sample you very rarely get anything like a true representation of what is in the syphon boxes.

14286. Although experienced men are employed to pump it?—Although experienced men are employed to pump it. Another point is that these deposits on the surface of the pipe absorbing these things again give them off in hot weather; so that you will find that where you have the weather at all cold, cold enough to have penetrated at all into the ground, you will get a considerable loss in illuminating power in going through foul mains, and you get a slight increase—you get that volatile matter being again taken up—when you get the slight warming of the ground again in warm weather.

14287. According to your experience, this loss should be very much more evident with smaller mains and as the mains diminish, because the surface would increase compared with the volume of gas, would it not?—Yes, that is so. I think in the 10 miles from Beckton to the City, the loss is not more than half a candle.

14288. What size main is that?—4½ feet.

14289. Is that admitted now by photometrists that it does lose half a candle between Beckton and the City?—It entirely depends upon which side the photometrist is talking.

14290. Speaking from your experience?—From my experience there is a loss.

14291. I daresay you are acquainted with the conditions in regard to that in other towns besides London?—Yes.

14292. Do you know Birmingham?—No.

14293. Do you know the average loss there?—No, but I should think it is high.

14294. Why?—Well, the mains have been laid there for some time (have they not?), and also they are using water gas enrichment there, and you find that in making carburetted water gas you have the temperature of the superheater in which you have the oil (being cracked, of course), running over a long grade of temperature; it is very hot at first, and perhaps it even overcracks the oil a little, and perhaps falls a little towards the finish, and then does not crack it thoroughly. If there is any oil vapour when this oil gets scrubbed out during distribution, that takes out a great deal of the illuminating power.

14295. You have described the mains in these cases as scrubbers?—Yes.

14296. You know, perhaps, do you not, that the gas loses about a candle in the middle of the town in the case of Birmingham?—I have not tested it.

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Mr. Vivian Byam Lewes.

29 April 1903.

14297. I mean from their own published results?—I have not seen them.

14298. I am speaking of about 10 years ago, which was before they used the enrichment so largely?—Yes.

14299. Have you had any experience in Manchester or Liverpool?—No. I remember a case at Southport, in which I tested the gas within 20 yards of the works, and tested it again a mile away, and I found a loss of one candle.

14300. Per mile?—Yes.

14301. Then you would not expect to get the actual lost candles in the form of benzol or other oils?—No, you never would.

14302. They never do as a matter of fact; but you would not expect it?—I should not expect it. There is a taking out and a giving up always going on.

14303. In your experience does bending at sharp angles in the mains make much difference or not?—Anything that will increase skin friction will increase it.

14304. You spoke just now about the cooling of the mains; I suppose wherever the mains come near to the surface there you would expect to find it?—Those are the most dangerous places.

14305. Have you had experience of that?—Yes.

14306. You would not be surprised to find a gas lose two candle power after going four or five miles?—No, it is quite a possibility.

14307. I suppose you know of worse cases than that?—Yes; of course where they use benzol enrichment it is a common enough thing.

14308. You mean where they do not crack it; where they are using benzol straight?—Where they are using benzol straight.

14309. There is no legislation of any kind upon that point, is there?—None whatever. The only legislation is that it has to satisfy the standard tests at the testing places; as long as the gas company gets it safe past that it is all right.

14310. You say in your opinion the best way in adding water gas would be to pass it through the retorts during carbonisation of the coal. Would you do that during the whole charge or only during a portion?—Only during about the first two hours of the charge.

14311. So as to hurry off the rich hydro-carbons?—Yes, while the rich hydro-carbons are coming off.

14312. Have you had experience of that?—Yes.

14313. Where are they working that?—I have made a long series of experiments at the Crystal Palace works. At the present moment it is in use at Tipton; I am not sure whether they are yet using it, but I believe they are going to use it at Cleethorpes and one or two places in the North of England.

14314. They are not using that at any London works yet, are they?—No.

14315. You would pass it through for about two hours?—For about two hours when the richest hydro-carbons are coming off.

14316. When the coal is red hot, I suppose no effect would be produced?—No; by that time the gas has become so poor that there would be nothing to save in it; if you tested the gas during four or five hours, you would find that in the last hour it is non-luminous gas.

14317. It is giving off hydrogen?—Yes.

14318. In giving the figure of 16 per cent. of carbon monoxide you have come down a little in your opinion, have you not; I think you used to give it as 17 per cent., did you not?—16 to 17 per cent.

14319. Would you say that it was to the advantage of most installations of gas to send out a gas of 12 to 14 candles instead of attempting 16 or 17, or more?—I think that with a supply of 12 to 14 candles power you can fulfil with coal gas everything that you desire.

14320. Therefore it would be economical both for the consumer and for the producer?—It would be economical both for the consumer and for the producer to take that candle power.

14321. (*Chairman.*) Would not that involve the use of mantles?—It would involve the use of mantles or special burners. If you take properly constructed burners for low candle power gas, you can get from the low candle power gas very often quite as much illuminant as you can from a higher one.

14322. That is not quite what I meant; supposing you change in a district from 16 candles power to 12 candles power, that would create some confusion and difficulty in places and as regards burners without mantles, would it not?—You could very often make the alteration without a single consumer knowing that there had been any alteration in the gas. The reason of that is this, that the burners which they use are, as a rule, so absolutely unfitted for the gas, that they are not getting perhaps more than eight or nine candles power out of the gas.

14323. That accounts for the largeness of their bills and the smallness of the light, I suppose?—Yes. I made one of the most interesting investigations, I think, that I ever made, in a large town in the North of England, where we had a regular house to house sort of census of the burners taken, and I got a man to collect for me some three or four dozen burners, taking them quite haphazard, and I think that, although the Company was sending out 20 candle gas, the highest power that any one of those burners would give was nine candles.

14324. (*Professor Dixon.*) They could not burn up to 5ft. with any of those burners, I presume?—One or two of them would burn up to 5ft., the majority of them only burnt 3½ or 4½.

14325. (*Mr. Bell.*) I should like to ask you one general question; whether 50 per cent. of this water gas is added or not, the general tendency of your evidence seems to be that there would be much less consumption of coal in the manufacture of gas than hitherto?—No, I do not think so, because you have a very steady increase going on.

14326. Apart from the increase there would be?—Yes, if you used a certain percentage of water gas you could undoubtedly reduce the amount of coal used for carbonisation.

14327. But do you think that the extra demand for gas will render the demand upon coal quite as much in future?—Even after that economy, yes.

14328. Would you say that it would be more than in the past; that there would be an increasing demand for the manufacture of gas?—The whole tendency at the present time is to an increase; people are using so much more coal gas now as fuel gas for stoves and things of that kind, that there is a very distinct and very steady increase going on.

14329. (*Chairman.*) May I put this question to you; I think it is not quite clear, but I understand your view is that the additional use of this water gas would very largely lessen the quantity of coal necessary to make a given quantity of gas?—Yes.

14330. And therefore apart, as Mr. Bell says, from the increased consumption, there would be a very large reduction in the quantity of coal necessary to be used in the production of the gas?—Undoubtedly.

14331. Therefore that would be the equivalent of so much saving of coal?—Yes.

14332. (*Mr. Bell.*) I wanted to get more clearly, if I could, an illustration of the increased light that people are demanding. If we take a room with three ordinary flat flame burners, consuming the usual 5 ft. of gas per hour per burner, with which we have been satisfied hitherto, and we suddenly found ourselves in possession of one incandescent light giving as much light as the three ordinary burners gave, would that be a fair comparison?—It would be a fair comparison, but no one would be satisfied with it.

14333. Would there be a disposition to still use two burners, according to your experience?—Yes, and generally three.

14334. Do people still burn two or three lights?—Yes.

14335. So that they really get twice as much illuminating power?—They get 30 or 40 times as much sometimes.

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14336. Out of the three lights do they get 30 or 40 times as much?—Yes, out of the three lights, because the supply of light by a No. 5 Bray burner would be 10 candles, and if you put on a Welsbach incandescent mantle, which is burning 3¾ cubic feet of gas and is giving you 60 candles, you are getting six times as much light there for a smaller consumption of gas ; and you find that instead of having that one burner giving 60 candles in place of the three, they will have a mantle put upon each of the three arms for the look of the thing, and in nine cases out of ten they will light two out of the three.

14337. That is your experience of the disposition and tendency of people?—Yes.

14338. They would have the saving in the gas bill assuming they burnt two out of the three?—If they burnt two out of the three they would be burning seven cubic feet of gas as against 15, saving one half.

14339. (*Mr. Briggs.*) You spoke of the carburetted water gas coming in ; if it was increased in quantity so largely, would there not be a difficulty in obtaining oil at a price that would make it commercially valuable?—It is the difficult factor which they have had to deal with in the last 10 years. When you speak of that you must not speak of carburetted water gas coming in, it has come in.

14340. No, but you speak of it being able to reduce the use of coal?—But that was one of the reasons ; I said if you are going to have any large increase in the dilution of the gas in this way, passing the plain water gas through the retort and letting it carburet itself, it would be a better and a more economical way of doing it than using the oil.

14341. Then if that is to take the place of coal it would have to be blue water gas?—That naturally would be so.

14342. Is there not this other point also, that gas coke, after all, is a very useful fuel now, and you will be using your gas coke, and the probability is that it would lead to a very big advance in the price of gas coke, and it might be checked in that way ?—That is one of the things which recommends the use of water gas to the gas manager ; you keep up the price of coke and you do not get any sudden slumps, as you very often do in the hot weather, in the price of gas coke. But there is this point to be remembered, that whereas a ton of coal makes 10,000 cubic feet of coal gas a ton of coke makes 66,000 cubic feet of water gas.

14343. For example, taking it in the North of England, where coke is selling upon terms as low as 8s. 6d. up to 10s. per ton, supposing we put it up to £1 per ton owing to the great consumption of gas coke in making water gas, it would still pay the gas-works, having regard to the fact that they have still the coke for sale ?—Yes.

14344. So that from every point of view the rise in the price of coke would never stop the use of that ?—Oh, no.

14345. Then with regard to benzol enrichment, you just spoke of that and said you held the view that it dropped its enriching power rather rapidly, I think ?—Benzol enrichment never can be so good a form of enrichment as permanent gas ; it is a vapour merely held up by its vapour tension, and you will always have the tendency to deposit.

14346. But still, it has been pretty well used ?—It has been very largely used indeed.

14347. And its use is rather augmenting now ?—You will find it used in many places where they are using water gas and mixing it with the coal gas.

14348. I suppose it is very adaptable ?—Yes, it is very adaptable ; because you have only to turn on a tap and bye-pass a portion of the gas through a benzoliser and then run it back into the main, and you can bring your gas up to anything you please. Where you have not got any very enormous systems of pipes to distribute it over it lasts perfectly well.

14349. Then you spoke also of ordinary flat flame burners being usually enormously below what they ought to be in their burning power. Surely the same remark applies to incandescent mantles with greater force, does it not ?—Yes.

14350. In my own experience my own mantles are never good for more than a few weeks, and I find them broken, or something happens, and no doubt they are giving off very much less light ?—Yes ; that undoubtedly applies to every form of burner.

14351. It applies quite as much to the condition of an ordinary burner ?—Yes.

14352. (*Mr. J. S. Dixon.*) I understand that the chief tendency of your evidence is that these improvements you have spoken of would lead to a reduced consumption of coal for gas making, that is to say, for the same quantity of light. Taking the gas coal resources of the country, may we look at what you have described as a means of saving these resources ?—You may look to those various processes for augmenting the output of the coal gas as distinctly likely to cause an economy in the coal used for the purpose of coal gas-making.

14353. (*Dr. Le Neve Foster.*) On the other hand, although you are speaking of coal, you have to buy oil for making this carburetted gas to enrich it ?—Undoubtedly. As I say, there is no economy really, or a very small economy to the gas maker in using the carburetted water gas except that it is a convenient method of enrichment, because of the oil he has to buy. That is why I think the blue water gas will, in the future, come in.

14354. With regard to the minimum of 12 candles power, is there any reason why one should not go lower than that ?—The reason is this : by taking your flat flame burner and putting into it a good broad slot instead of a narrow slot, and by putting in a small regulator so as to keep the pressure of the gas low, you can get a very fair illuminant from 12 candles power gas ; but if you go below that you cannot. There are certain places where you have the swing bracket, where it is almost imperative to use a flat flame burner, and you could not use an incandescent mantle because you would have it knocked over every time you used it ; and for other general purposes of that kind it would not be well to go below 12 candles power. But there are many towns in England where the gas is down to 12 candles power and where still the flat flame burner is one of the chief burners used.

14355. With regard to the last portion of your evidence, the manufacture of gas from oil processes, I gather from what you say that gas manufactured from oils, such as the Kitson, is almost the cheapest illuminating power known ?—The Kitson process is the cheapest illuminating power known ; whereas with coal gas and the incandescent mantle with high pressure lighting you get 1,000 candles power for about 1½d., I think with the Kitson you get the same power for 1d. now.

14356. (*Chairman.*) But is that applicable to anything but those large quantities ?—No, it is for big units of light. You would have to go down to petroleum spirit processes.

14357. (*Sir George Armytage.*) Will you tell us what, in your opinion, is the effect on the atmosphere of a room of the use of mantles as against the use of an ordinary burner ?—It has been several times said that there are minute traces of products of incomplete combustion, but I have never been able to trace it ; I have never been able to find any sign of carbon monoxide from the mantle.

14358. What do you say as regards temperature?—As regards temperature there is not so much heat.

14359. That is from the mantle?—From the mantle you are burning a smaller amount of gas.

14360. Then as regards dirt and blacking the ceiling?—The blacking of the ceiling is not due, as is commonly supposed, to escaping carbon from the flame ; it is due to the carbonisation of dust in the air, which dust passes upwards with the ascending current of heated air, and, the plaster of the ceiling being porous, it diffuses through, and the carbonised particles being filtered off blacken the surface. You can see that perfectly well where you have a ceiling with beams behind it ; when the ceiling gets blackened with the burners in the room, you very often see those beams mapped out on the ceiling.

14361. Then as regards the destruction of your leather bindings of books, and that sort of thing, do you think they are improved at all by the use of the mantle ; does the mantle in any way catch up any of that?—The mantle will not catch up anything, but it will be improved in the ratio of the saving in volume of gas consumed.

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Mr. Vivian Byam Lewes.

20 April 1903.

14362. You mean you burn less gas?—You burn less gas and have less products from it.

14363. (*Chairman.*) Then you do not hold the view that it is the unconsumed products of the gas which produce those injurious effects?—Oh, no.

14364. (*Mr. Bell.*) I should like to ask you one general question in view of the statements you have made about the Kitson light being the cheapest illuminant known, and with regard to the development of light by these burners; have you any opinion as to the future of electricity as an illuminant in competition with gas?—Electricity is going ahead so fast, and is being generated in so many central stations now for traction work, that of necessity the illumination goes with the traction under those conditions, and therefore undoubtedly you will have a very large amount of outside illumination done by electricity. But where you have a town in which you have not electric trams running or any reason for the production of electricity on a large scale, there undoubtedly big units of light, such as are obtained by the Kitson process, are of enormous value for the outside illumination and for giving you the power of putting in that illumination without tearing up all your roads.

14365. Then with regard to the interiors?—With regard to the interiors I think you will never have anything which will entirely take the place of coal gas. As electricity becomes cheap it will spread more and more, but it will never take the place of coal gas in the smaller parts of a town.

14366. In the middle-class houses, more particularly with the very cheap cost of gas bills which might be obtained by economy of light, is there a reduction in the demand for installing electricity in houses?—I am no authority upon electricity, but I should think in all probability it is not spreading fast; it is more a luxury, and you find that when you get below the middle class the fact that heat is obtained as well as light from the combustion of gas is an enormous factor in pressing it forward.

14367. (*Mr. Briggs.*) Supposing you put 50 per cent. of water gas into coal gas (and there is a considerable consumption of gas for gas engines), would that make any difference, or would the mixture of water gas do sufficiently well with coal gas for engines?—No, you would require a rather large consumption.

14368. But the engines designed for the use of coal gas would still work with the other?—Perfectly well.

14369. And therefore it would be a matter of price only?—Purely a matter of price. I think I can give you the ratio; the general run of figures is as follows: For power production in engines per brake horse-power, town gas, 13 to 17 cubic feet; carburetted gas, 15 to 19 cubic feet; and straight water gas, that is, blue water gas, 30 cubic feet. Then of course with Dowson and Mond gas we get from 70 to 90 cubic feet.

14370. So that it is simply a matter of price?—It is simply a matter of price.

14371. What do you say about the trouble in the slight smell from the burners that you are speaking of; would it be due to bye-passes in very many cases; they leave a nasty smell in a room?—Do you mean the smell from incandescent mantles?

14372. Yes.—If you get a bye-pass which has gone out you get a distinctly unpleasant smell from it.

14373. Is a bye-pass a mistake?—I think a bye-pass is a mistake; it ruins your mantle in nine cases out of ten, and it is very often out when you want to light the gas.

14374. (*Chairman.*) It does smell even if it does not go out.—I think so, too.

14375. (*Dr. Le Neve Foster.*) And it ruins the mantle?—It ruins the mantle.

14376. It is taking up a current of dust?—Yes.

14377. (*Mr. Briggs.*) However, people are generally doing without them now?—Yes, they are doing without them; there is a comparatively small number now made

TWENTY-FOURTH DAY.

Thursday, 30th April 1903.

PRESENT:

Sir GEORGE ARMYTAGE (*in the Chair*).

Sir LINDSAY WOOD.	Dr. LE NEVE FOSTER.
Mr. BELL.	Professor HULL.
Mr. BRIGGS.	Mr. TEALL.
Professor DIXON.	Mr. YOUNG.
Mr. J. S. DIXON.	

The Secretary.
The Assistant Secretary.

Mr. HENRY BERNARD HELBING, F.C.S., called; and Examined.

Mr. Henry Bernard Helbing, F.C.S.

30 April 1903.

14378. (*Sir George Armytage.*) You have come, I believe, to give us some information on the solidification of petroleum?—Yes.

14379. Will you kindly tell us shortly what your invention is?—The invention consists in the emulsification of petroleum with a salt of casein which turns it into a solid mass, which can afterwards be hardened with formaldehyde. Hitherto nearly all the so-called solid petroleums have been mixtures of petroleum with absorbent materials containing a good amount of inorganic matter with which the petroleum was, so to speak, loaded and soaked up; and which after all contained only a comparatively small percentage of petroleum. The invention which we have before us here is of quite a novel character, because I believe we are the first to incorporate successfully as much as 90 per cent. or 95 per cent. of petroleum with practically nothing else than organic matter, and at very little cost, so as to turn the liquid petroleum into an absolutely solid product. The process being simple and very cheap, there is no reason why it cannot be carried out anywhere, no particular skill being required for doing so. The materials which have to be used are also obtainable in any quantity, casein being obtained from milk, and formaldehyde being a product which is obtainable in unlimited quantities. The product obtained has some very surprising properties, because it seems a very extraordinary thing that you can take 90 or 95 parts of petroleum and, so to speak, keep those 90 or 95 parts of petroleum in suspension with as little as two parts of casein, with practically no addition to it

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except a small percentage of water; the formaldehyde not only being required to hold the petroleum in suspension and thoroughly mixed, but also to harden the casein, which then forms a kind of firm skeleton around the petroleum, and the petroleum becomes quite a firm and solid texture. I should like to show you some of this petroleum. *This* is ordinary burning petroleum (*the witness produced sample*), which for all purposes contains from 90 per cent. to 95 per cent. of petroleum and from 2 per cent. to 3 per cent. of casein, the rest being moisture.

14380. Does it give off no inflammable vapours?—It gives off no inflammable vapours. You can light this material very easily; you can blow it out as often as you like almost in the same way as a candle (*The Witness lit the petroleum.*) You will find it burns as long as you like, and leaves practically no ash, or very very little, because there is only a very minute trace of alkali in it.

14381. Has this been used in practice in fire-grates?—It has not been used in practice on a large scale, but you can burn it. As you see, it burns very quietly, and most curiously, there is no running from it. There is absolutely no petroleum running out of it; the petroleum is very strongly kept in.

14382. Has this been used in a domestic fire-grate?—We have in a small way used it in a fire-grate, that is to say, using small pieces like this, without any difficulty. I should like to show you that practically this substance keeps the petroleum. (*The Witness put some water in a glass which he placed over a spirit lamp.*) I am going to boil the water, and I want to put a piece of this material in, in order to show you how very tightly the petroleum is kept by the casein in the emulsified state.

14383. Have you made any comparison regarding the value of this as compared with coal?—No, except that of course it burns without splashing and without running, and it can be burnt like ordinary coal, and of course we presume that it stands to coal in the same proportion as petroleum stands to coal in the ordinary way—if anything, somewhat better.

14384. Can you say anything at all about the quantity which can be stored in a given space as compared with coal for the heat given out?—The quantity would be identical with the quantity of petroleum. I have not calculated that out as far as the actual storing capacity goes as compared with the actual space occupied by coal.

14385. What space does it occupy in its solid state as compared with the space that it occupies in its liquid state?—The same space.

14386. That means to say that, if you have a gallon of petroleum, it would be the same size?—Yes.

14387. (*Mr. Briggs.*) Provided it could be packed without loss of space between the blocks?—Well, so it can, practically.

14388. You could not get a solid quite as close as a liquid?—No, but there is no need to make blocks of it; you simply make your material, and turn it into trolleys wherever you want it, and there you have it, and there you can carry it along.

14389. (*Mr. J. S. Dixon.*) And dig it out as you want it?—Yes, you take it out as you want it with a spade. (*The Witness produced blocks of petroleum*). You will see this is not a solid block like a brick, and therefore it would not do to make so many blocks which want time to harden like this, but you can simply put it in whatever shape you like, and take it out.

14390. (*Mr. Briggs.*) This is almost a jelly?—Well, it is not like a jelly in this respect, because you see the great point is that you can burn it in that way, and it does not melt, and does not run.

14391. (*Sir George Armytage.*) In what quantities have you made this?—We have made it in comparatively small quantities—I mean, a gallon or two at a time—but there is no difficulty in making it on a very large scale.

14392. I mean you have not made several tons?—No, we have not.

14393. (*Mr. Bell.*) What is the weight of a block?—I should say the weight of this block is about 2lbs., if not more.

14394. Do you know how long that would burn in a grate?—No, I do not. Of course that depends very much on the grate itself, and on the draught.

14395. (*Sir George Armytage.*) Would your blocks be limited in size?—No. My belief is that if this is done on a large scale, you would not make blocks of it; you would simply make the stuff and use it there and then. It is very simply made.

14396. Supposing that this was used, we will say, for ships, how would it be stored—in large blocks?—No, it would be simply made and turned into the bunkers or into casks.

14397. Into the steamships in bunkers?—Yes.

14398. And dug out?—Dug out or taken out. What could be done is this: if you have, for instance, tanks on board ship you can, with a very small installation, turn your liquid petroleum into solid, and simply carry it along and burn it.

14399. What advantage would you get by turning the liquid into solid?—You would get this advantage, that you could burn it in an ordinary grate instead of having special appliances.

14400. That would be just the difference?—Yes, and you could burn it, so to speak, alternatively with coal.

14401. But inasmuch as the burning of liquid petroleum in grates is a great saving of labour in the way of reducing the number of stokers, would not this take you back again, as it were, to that point where you were before: more stokers would be required than in the case of liquid oil?—No, you would save as against coal in this way, that while you have to take the coal out of the bunkers, and want, therefore, manual labour, this would be turned out automatically—put into trolleys or whatever you use for that purpose—and you would not require to take it out by hand. It would run from the machine.

14402. It would not be so heavy to handle?—It would not be so difficult to handle; it would be handled automatically, because you would make it in a big machine or tank, and tip that tank and let the stuff run straight into the vessels or into baskets or into trolleys, which could be taken direct to the stokehole.

14403. We have heard that the quantity of petroleum that could be carried in a vessel is about double the quantity which can be carried in the shape of coal, I think?—Yes.

14404. Do you contend that this being equal in capacity with petroleum you could carry in the same vessel sufficient of this to take that vessel twice the distance that coal would take it?—As a matter of fact, even more, because you get more heat out of petroleum than you get out of coal.

14405. (*Mr. Briggs.*) Double?—Yes, double.

14406. (*Sir George Armytage.*) Have you any idea about what the price of this is as compared with coal? What do you consider its market value would be if it comes on the market?—That is a question which it is very difficult to answer. I can tell you what I believe it would cost to produce a ton of this, which, according to circumstances, may be from 10s. to 20s. per ton without actual labour or steam.

14407. (*Mr. Young.*) You mean the labour of conversion?—I include the ingredients and, say, the actual process—but not in steam.

14408. (*Sir George Armytage.*) Then the cost of conversion would, in round figures, be equal to the cost of the petroleum?—Well, if you get petroleum at 10s. to 20s. per ton.

14409. We have had evidence with regard to petroleum at about 25s. per ton as being a marketable price?—Then I should say you could fairly put this at 40s., not allowing for the working of the machinery.

14410. Shall we take it in round figures that it would be somewhere about twice the price of the liquid petroleum?—No, I do not think so—if you say 25s. is the price of petroleum.

14411. Could you tell us about what percentage it would be?—If you say 25s. is the price of petroleum I should say it would be from 10s. to 15s. more; it will depend entirely; if you work on a large scale we have

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Mr. Henry Bernard Helbing, F.C.S.

30 April 1903.

every belief that the working can be very materially reduced, and it may go as low as 10s. Then, as against that, you have the saving, that you do not want any special installation or arrangements such as you want for liquid fuel; you may arrange a grating which will very likely do for both coal and petroleum.

14412. What have you in your mind as to the practical value of this—principally for ships?—Principally for fuel, whether for ships or wherever it may be wanted.

14413. Have you considered how it may be used as regards locomotives?—I have not considered it except that I simply say here is a material which has many and very considerable advantages over ordinary petroleum or liquid petroleum, and I should say that if once put to a practical test it certainly will be of considerable value. There is no ash left, so that you have all that difficulty of clearing out your grating done away with, which is a considerable saving; and, taking it all round, we believe that if the thing is tried on a practical scale it will show decided advantages.

14414. Have you made a sufficient quantity to enable you to try it in a locomotive?—No, but I have considerable experience of this particular kind of manufacture, and I am perfectly convinced that manufacturing it on a large scale you would have no difficulties. As a matter of fact very large savings will usually be found if you manufacture these things on a large scale.

14415. Have you made any tests as to the quantity of water evaporated as compared with coal?—No, I have not. I should like to show you now how really strong this material is, and how practically nothing gets out even in the ordinary way of distillation.

14416. You see what we want to arrive at, and what we have to inquire into, is the quantity of coal there is in the country, and what probabilities there are of anything else taking its place, and as to how long it will last; and what we should like to get, if we can, would be some practical views as to whether this or any other material is likely to prolong the period for which the coal may be expected to last?—Well, as petroleum is the next product which you have to consider, I should say——

14417. Yes, but what I really want to point out is that you do not seem to be able to give us any actual facts as to what this is capable of doing, comparing it with coal?—It is capable of doing that which petroleum does in comparison with coal, which I say is roughly double.

14418. (*Professor Dixon.*) Can you recover the liquid from this solid form?—Yes, you can recover it under a certain amount of pressure and friction together. I will show you how. I will take a piece of this petroleum and you will see if you press it and at the same time use friction—you have practically to tear it all to pieces—it drops down in the form of perfectly clear petroleum. (*The Witness squeezed the piece of petroleum, which passed into a liquid form.*)

14419. I understand what you really have is a skin round each little globule?—For all practical purposes it is a skin or little cell round each globule of petroleum.

14420. Have you any lime in it?—No, none.

14421. What alkali do you put in?—Ordinary caustic soda; we only use the caustic soda to make the casein soluble. You see we make a salt of the casein and that is all, and in the usual way we use something like 2 per cent. of casein, but you can use 1 per cent. of casein, and the less you use the more you reduce the cost.

14422. Then the formaldehyde solidifies it?—The formaldehyde is only used as a hardening agent on casein in the usual way.

14423. There is absolutely no chemical in these blocks at all?—There is no chemical combination at all. The remarkable thing is this: I have here three different kinds of petroleum; this is ordinary benzine, the most inflammable benzine you can have, and you see the inflammability is very much reduced or practically done away with, which is, of course, a very great point with petroleum. (*The Witness lit a sample and blew it out and re-lit it several times.*) You do not get one flare up.

14424. (*Mr. Teall.*) Is that benzine?—That is benzine.

14425. (*Mr. Briggs.*) You solidify benzine in the same way?—Yes, in the same way. I show here three grades, benzine, the ordinary petroleum, and some crude petroleum. The crude petroleum gets much harder.

14426. (*Professor Dixon.*) What is the dark substance you have?—That is some crude petroleum.

14427. Is that Russian?—It is Texas as far as I know; but they all solidify, and the crude petroleums do so even better than the ordinary petroleums. There seems to be more body in them, and you want less casein. I should like to say, if I might deal with that point, that the question of cost will entirely depend, of course, on the amount of casein you have to use. The less casein you use, the less formaldehyde you use; and on a large scale it is quite possible that the percentage may be reduced to 1 per cent. or even less—to ½ per cent. or ¾ per cent.—which means, of course, that the price which I stated, say 15s. per ton, may be 7s. 6d. per ton; only, as you will quite understand, I do not like to make statements in theory as to a process which I have not carried out on a large scale.

14428. You give up all the advantages of the liquid as far as movement in bulk is concerned?—Yes, we give those advantages up because we understand that it is solid petroleum which is required. Hitherto no solid petroleum has existed which has anything like approached this petroleum in percentage and in its properties; you have 95 per cent. or 90 per cent. of petroleum and you have no ash.

14429. (*Dr. Le Neve Foster.*) Then, as I understand the chief advantages you claim are that you can burn it in the same grate as coal; that is one?—Yes.

14430. The other is that it gives off no inflammable vapour, and is therefore safer?—Yes.

14431. Is there any other advantage?—Well, generally speaking, those are the chief advantages.

14432. Then one of the disadvantages is that it is less easily fed into boiler furnaces than liquid fuel; that is one?—Well, of course, if you once have your installation arranged for liquid petroleum, then I daresay it is more difficult—you see you have more stoking. But this will have a very great advantage in any arrangement by which you can use alternatively coals and liquid petroleum and this in the same way; for you can then burn coal, and supposing you want a fiercer heat and a higher speed, here you have a material which you can at any moment use, and shovel in even along with coal.

14433. We have been told that you can easily convert a boiler or grate or furnace which has been used for burning liquid petroleum into one for burning coal, and *vice versa*; if so, the disadvantage would disappear?—Yes, but it could only be converted, I presume, by letting the fire out and removing certain appliances; but here the idea is that you would be able to burn coal, and supposing you ran short of coal where you were not near a coal station, then you could use solidified petroleum if you had it in a tank, or you could also use it when you want to get a higher speed; or you could use coal directly without any interruption all the time, and in the same grating where you burn your coal you can use the petroleum.

14434. But in order to get that advantage you have to pay a considerable extra cost?—You would have to pay an increased cost, decidedly; but I believe that this increased cost which I speak of here as between 10s. and 20s. (say 15s.) would on large quantities be very materially reduced.

14435. Yes, but it would not go down to less than 5s. per ton, I suppose?—I do not think so.

14436. Then it would be just the point whether it would be worth while paying 5s. per ton for the increased advantage of getting interchangeability with coal, and not giving off inflammable vapour?—That is so.

14437. That is how it stands, is it not?—Yes.

14438. (*Mr. Briggs.*) The petroleum which we see solidified in a block there is, I presume, burning oil?—Ordinary burning oil.

14439. Then we are quite wrong in our estimate of cost, because that is worth many pounds per ton above the price of the petroleum of which we spoke at 25s. per ton, which is the very cheapest residuum?—Well, that is what we have here (*pointing to one exhibit*).

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14440. Burning oil would be worth at the very least £5 to £6 per ton; therefore, it would be utterly hopeless as a fuel in competition with coal?—Quite so. I only show this because it is a cleaner way of making it, and because I did not wish to soil anything with the black material.

14441. Then you consider the black material which you have there could be made equally easily?—Yes; as a matter of fact it is more easily made, because it is not so limpid; it has more body in it.

14442. Is it soft also in the same way?—Yes. I may tell you this is a very hurriedly made specimen, which was only made three or four days ago, and it is not even so hard as the other; but you will find it is comparatively easy to make it harder.

14443. That has the same burning properties which the other has?—Yes.

14444. Have you considered it with regard to making candles or anything of that sort?—No practical experiments have been made in that direction.

14445. Then is this benzine ordinary commercial benzine?—No, it is benzine out of the petroleum.

14446. It is not benzine out of coal tar?—No.

(*Mr. Briggs.*) It smells very much like it.

14447. (*Mr. Young.*) If you made candles of that petroleum would not the smoke be much greater than from the ordinary candles that are made?—Well, I presume so. I have not made candles of it, so that I cannot answer that question.

14448. Would not the smoke from that be much greater than from coal?—No, I think quite the reverse. That is even a point to its advantage. You see we have with this solid petroleum a certain amount of moisture which would tend to a greater combustion, and would even give a slightly increased heat and less smoke.

14449. The smoke which proceeded from that which you were burning seemed rather dense compared, I should think, with smoke that would come from coal when it was properly burnt?—The smoke which comes from this which I was burning is simply the smoke which you obtain from petroleum—not more, but if anything, less, because you have a better combustion through the addition of water.

14450. (*Sir Lindsay Wood.*) Has temperature any effect upon it?—No, not at all; and that is the most extraordinary thing. You see I have boiled that for some time without it showing any effect (*referring to the piece of petroleum in the boiling water*). This is in just the same condition as it was before, and for all purposes you can burn it in the same way again; you can take it out and put it aside. (*The Witness lit the piece.*)

14451. Then heat in the bunkers or anything of that sort would not have any effect upon it?—No, it does not run out and it does not melt.

Mr. Henry Bernard Helbing, F.C.S.

30 April 1903.

14452. (*Mr. Bell.*) If you were to place that 2lbs. square into the stove or grate and light it, how long do you think it would burn?—A considerable time. I should not like to give you an estimate, but I shall be very happy to try it.

14453. Would it throw out a great amount of heat?—Oh, a tremendous heat.

14454. (*Mr. J. S. Dixon.*) I was going to suggest to you that there might be a good opening for you in using this material for lighting fires, in the form of little blocks?—I should like to show you now, really, how it is made, because it is a very nice experiment.

14455. (*Mr. Bell.*) It would not take long, I suppose?—No, it would not take long to show how it is emulsified; it is a very easy and very neat experiment.

14456. (*Sir George Armytage.*) I think it would be more advantageous to us if you could tell us shortly how much it costs to make it, rather than that we should have an actual illustration of the method of producing it. I am afraid we have not much time to go into that?—It does not take long.

14457. (*Professor Dixon.*) How long would it take?—Ten minutes.

14458. (*Sir George Armytage.*) I think we can hardly spare time for that, thank you. Have you made any estimate at all as to the relative cost of stoking as between this fuel and liquid fuel in ships?—No.

14459. But I suppose we may take it it will naturally require more stokers to apply this to the fires than it will to apply oil, which is simply pressed on?—I should say so, because oil usually is only automatically used.

14460. Do I understand that what is running in your mind as regards the supply of this oil for ships would be that the ship would take on board the liquid fuel and then make it into this solid fuel on board the ship?—Yes.

14461. About what quantity of room would be required for the plant?—I should say for all purposes, a space like the front part of this room would be more than ample?—

14462. Do you mean half the size of this room?—A quarter of the size of this room would be ample to make tons of it.

14463. Then may we say a space 20ft. square and 10ft. high?—Yes.

14464. What quantity would that produce—how many tons per day?—Well, it depends entirely upon your machinery; but you can easily go to 10, 20, 50, or 100 tons a day. It is an unlimited process; once you have your machinery running you can go on and repeat that process.

14465. Fifty tons a day would not be much use on a large ship?—Well, you must increase your space and increase your machinery.

(*Sir George Armytage.*) We are very much obliged to you.

Mr. Walter H. Thew, called; and Examined.

14466. (*Sir George Armytage.*) I understand you would like to say a few words with regard to the commercial part of this matter of solidified petroleum?—Yes; I should prefer to answer any query that you put.

Mr. Walter H. Thew.

30 April 1903.

14467. Really, the practical question that we want answered is what is the price of this?—My friend, Mr. Mitzakis, who is here, who is associated with me in this enterprise, is largely connected with petroleum, and I should like him to take my place, if possible, and answer directly any question with regard to the actual cost of the crude material. But I wish to supplement what has been said by Mr. Helbing from the chemical point of view, by pointing out that in commercially handling this article the question of insurance must be extremely important. We have here an article which, in this form, is practically no more inflammable than wood, and there is no waste and no loss of volume in storage. Besides which there are a number of points in this connection which we ought not to forget. In use in boilers and furnaces you have the great advantage of having an interchangeable fuel with coal; coal can be used, or this solid material can be used, whichever happens to be the cheapest at the moment. Then again in use in a furnace the furnace is constantly kept clean, while with coal, of course, it is not. Therefore, beyond the actual extra heat units that there are in this petroleum as compared with coal, you get a greater effect by having a furnace always free from clinker, and so the water gets all the heat units.

14468. That is the case also with the liquid petroleum, is it not?—It is, but the disadvantage in using the liquid petroleum is that first of all there is the question of insurance, next there is the question of special apparatus, thirdly you cannot use the two fuels in conjunction, and you can only use coal in such a furnace by allowing the furnace to cool and removing the apparatus and starting afresh. But a very great point, of course, is the saving in waste; there is no vapour given off in storage.

14469. Have you represented this material to the Admiralty or to any large shipowners?—I have addressed a letter to the Admiralty only a very short time ago, and a reply, I think, is just about due from them.

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Mr. Walter H. Thew.

30 April 1903.

14470. I suppose we may take it that, generally speaking, large shipowners like the Atlantic lines and any firms of that description would naturally, in the first instance, ask you whether you can show any economy by using this fuel ?—Naturally. The article is quite novel. I have personally not yet approached any large shipowner, but a large shipowner has approached me, and he is prepared to place at my disposal a large ocean-going steamer and to bear the cost of an experiment.

14471. Is that trial likely to come off ?—I think it will take place in about a week or a fortnight.

14472. When that trial does take place, would you have any objection to communicating with us, and letting us know what is the result of it ?—No; it will be my pleasure to do that.

14473. It appears to me that that is a practical way of looking at it, is it not ?—Yes. I am glad to mention this point, in order to show you that the commercial value of the thing is thoroughly appreciated by practical men.

14474. Yes, but when the trial does come off, we shall have some reliable figures to go upon, shall we not ?—Much more than you have now, certainly.

14475. Would it not also be well, if you could do so, to ascertain the comparative value of this material as a heating fuel with regard to the quantity of water evaporated ?—Yes. Of course, there is nothing better than a practical test; any amount of theory goes for very little.

14476. Quite so.—And an ocean-going steamer sailing round our coasts with a certain amount of this fuel on board, and doing so successfully, would be a trial from which one could judge.

14477. Or a journey to New York and back would be better still ?—Yes, of course.

14478. (*Mr. J. S. Dixon.*) I should like to impress upon you the view we take of this trial. Our object here, as you will understand, is to see whether the material of which you speak will in any way supplement a certain amount of coal. We are dealing with the coal resources of the country ?—Yes.

14479. If you can demonstrate that, we shall be very pleased to know the result of the experiment. We wish to know whether this material is likely to be used and to displace a certain amount of coal. That is the whole object of our inquiry.—Of course, I could better answer that after the practical demonstration of which I am speaking has taken place. There is one matter I should like to suggest: if the Commission could only give time to it, I should like the Members of the Commission to actually see how quickly the thing is made, and they would then be able to form their own opinion as to the cost of the process.

14480. (*Sir George Armytage.*) I think we may take your word for it that it can be quickly made ?—Yes, quickly and easily. Personally, I think the estimate made by Mr. Helbing is a very cautious one; as a chemist naturally he speaks with a great deal of caution, but I think on a commercial scale the cost will be found to be less than he spoke of.

14481. Do you think it will be below 5s. per ton ?—Well, I think it will approximate to that.

Mr. JOHN MITZAKIS, called; and Examined.

Mr. John Mitzakis.

30 April 1903.

14482. (*Sir George Armytage.*) What is it you wish to explain to us ?—I think that the practical test which we shall make in a fortnight or twenty days from now will prove that although the price of petroleum is double that of the existing price of coal, the results of its use in this form will be double, perhaps three times greater. Further we shall have another fuel that we shall be able to burn alternatively with coal. The great difficulty of liquid fuel being adopted in England and elsewhere is that manufacturers cannot change their plants; but if solidified oil is used you will have an alternative fuel which you will be able to burn with better results, and without any alterations in your plants.

14483. In fact, what you mean is that you can interchange this material with coal whenever you like in the same furnace ?—In the same furnace, as they stand to-day.

14484. We understand that?—The shipowners who have approached me think that this will at once replace coal in cargo-boats, and they have placed at my disposal a steamer of from 4,000 to 6,000 tons, which will be in London in a few days. We shall reduce the petroleum into a solid state on board the ship, and we shall go from here to Cardiff. A steamer of from 4,000 to 6,000 tons burns about 60 tons for two or three days, or from 60 to 100 tons; so that we shall solidify about 100 tons on board. If the Members of your Commission wish to be present, we shall be much honoured if you will accept an invitation to see the practical tests.

14485. And you will let us know the results as soon as you can ?—Yes.

Mr. BENJAMIN HOWARTH THWAITE, called; and Examined.

Mr. Benjamin Howarth Thwaite.

30 April 1903.

14486. (*Sir George Armytage.*) You are, I believe, a Civil Engineer ?—Yes, I am an Associate Member of the Institution of Civil Engineers, and a Fellow of the Chemical Society.

14487. You will give us some information, I understand, upon the evolution of the process of the manufacture of blast furnace gas ?—Yes.

14488. In the year 1894 you first realised the value of this gas ?—Yes. In the year 1894 I first realised the great value of carbon-monoxide as the ideal thermal agent for direct power production in internal combustion engines. May I hand in these prints of my lectures as I am referring to them ?

14489. Yes, will you please do so ?—(*The Witness handed in book.*)—Years before I had, in lectures on "Gaseous Fuel," explained the latent heat disadvantage of hydrogen and hydro-carbons, and the advantage of carbon-monoxide, in this non-latent heat loss respect. In 1894 I realised by extended experimental investigation that the slow inflammation characteristic of carbon-monoxide developed a card or indicator diagram that was almost ideal for the transformation of heat into work, in gas engines.

14490. (*Mr. J. S. Dixon.*) Will you explain that diagram at this point ?—You mean the first diagram ?

14491. Yes; you speak about an indicator card or diagram which is almost ideal for the transformation of heat into work ?—This diagram (No. 1) is the indicator of gas of a very high explosive quality, such as hydro-carbons. Diagram (No. 2) is the carbon-monoxide diagram.

(*The Witness produced the following diagrams*):

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Mr. Benjamin Howarth Thwaite.

30 April 1903.

DIAGRAM No 1.—Too early firing.

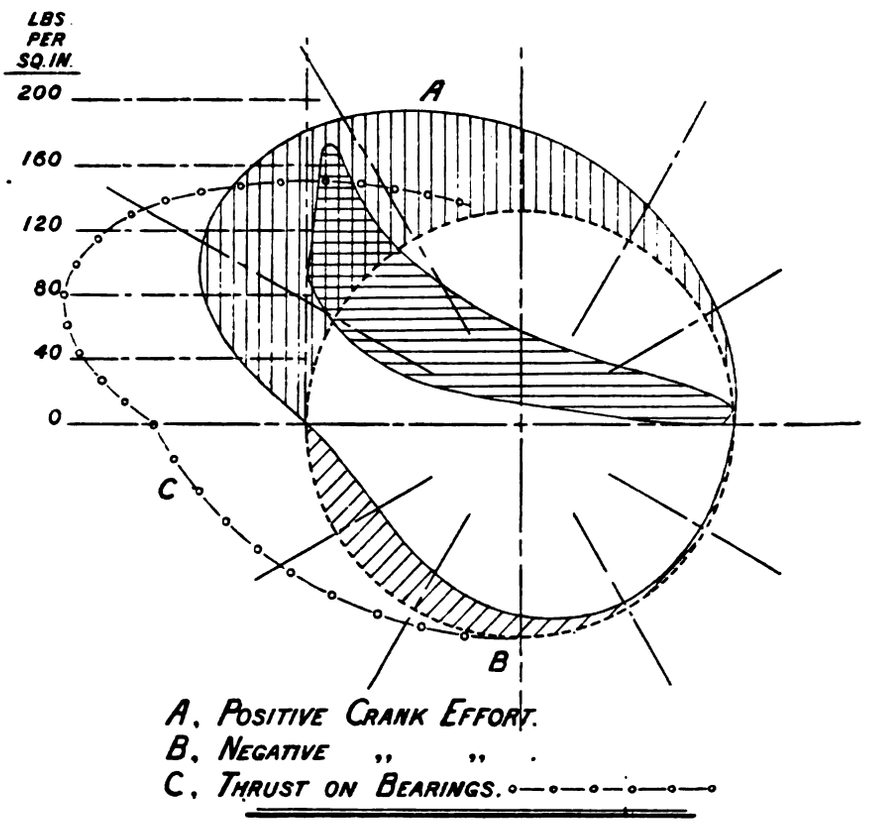
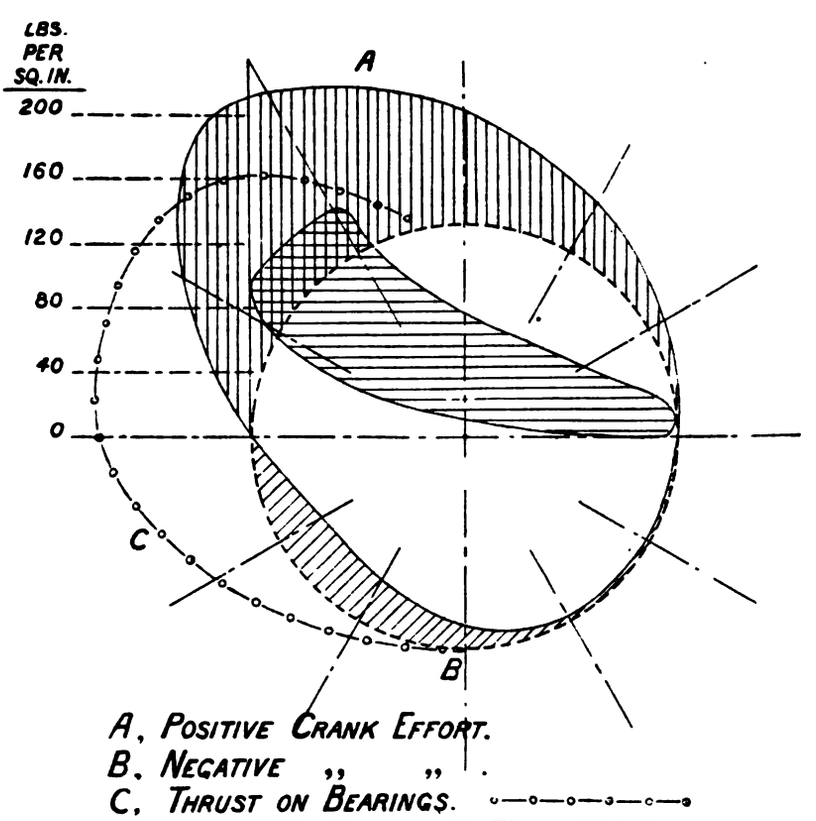


DIAGRAM No. 2.—Ideal Card—Blast Furnace Gas—Delayed Ignition.



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Mr. Benjamin Howarth Thwaite.

30 April 1903.

14492. No. 2 appears to be similar to a steam engine diagram?—Yes, it is very much like a diagram showing the expansion of ordinary steam.

I also proved that carbon-monoxide as a combustible agent diluted with 70 per cent. of inert gas could be compressed up to eight atmospheres without danger of self-ignition. Further experiments proved that even if this gas was diluted with four times its volume of inert gas, equivalent to 80 per cent. inert gas, it could be compressed or increased in density to a degree that secured its immediate ignition in a gas engine cylinder, even when the speed of the piston represented 80 Otto cycles of operation per minute.

These facts led me to investigate the characteristics of the gaseous effluents from iron-making blast furnaces, and the investigation led to my invention of 1894, patented in May of that year.

But before continuing the history of this invention, which admittedly is destined to effect great and economic changes in methods of power generation from the combustion of fuel, further reference may be made to the intrinsic advantages possessed by carbon-monoxide gas, advantages which in their culmination explain the almost marvellous development of the use of blast-furnace gas for the direct generation of dynamic power. The form of the indicator curve representing the pressures produced by the inflammation of carbon-monoxide gas is more under control than that resulting from the burning of hydrogen or hydro-carbons. Graphically, the former may be said to take the form of a camel's back, whilst the latter assume the sharpness and abruptness of Alpine mountains. The great sensitiveness of hydrogen, an advantage perhaps for securing rapid ignition, is almost fatal to the possession of a sufficient control to permit uniform and mild developments of pressure to be obtained, whereas it is possible to control the form of the card indicating the pressures set up by the combustion and expansion of carbon-monoxide, and its oxygen agent, so that it almost takes the characteristic form of an expansion steam card. The diagrams show the value of the CO (carbon-monoxide) card in adding increments of energy to the crank such as to reduce the waste energy hammering of the crank pin and secure the highest possible transformation efficiency of reciprocative into rotative energy.

If you will allow me to refer to the diagrams again, you will see that where hydrogen fires, say at the dead centre—(*describing on diagram* No. 1)—you have a tremendous explosive effect, which results, of course, in a serious amount of friction and loss of energy. In the other diagram, using blast furnace gas, the explosion is much more slow, and before the maximum explosive effect is realised, the crank has got round to a position in which it can receive it, and it is in the best condition to turn over. The result is, that not only is the tendency to overheating of the crank pin reduced, but the mechanical efficiency of the motor is higher. As the thermal result following each compression *per se* is constant, and the combustible proportion of blast-furnace gas is almost entirely carbon-monoxide (87 per cent. to 95 per cent.) the indicator diagrams may be so controlled as to be almost exactly identical in form, and consequently in area, and a greater cyclical regularity than has hitherto been thought possible, is obtainable and can easily be secured.

Briefly summarising the advantages, we have with carbon-monoxide gas: (1st) after combustion only the thermal loss due to its sensible heat, no latent heat loss: (2nd) an ideal and controllable expansion curve securing steady running: (3rd) a greater mechanical efficiency output: (4th) less liability to pre-ignition with high compression: (5th) after compression perfectly reliable and controllable ignition.

Low combustible value or power gas, relying for its thermal effects on its 20 to 30 per cent. volumetric percentage proportion of carbon-monoxide, will sometimes actually refuse to ignite at ordinary atmospheric pressures, but it ignites with unfailing regularity after compression.

Blast-furnace gas is fairly represented by the following analysis:—

	Per cent.
(CO_2) Carbon-dioxide - - - -	6
(CO) Carbon-monoxide - - -	27–30
(H) Hydrogen - - - - - -	1–2

I realised that the gas would require special preparatory treatment; this opinion, which was formerly contested by continental engineers, is now universally accepted as correct and is always followed.

In 1894, Sir Lowthian Bell was satisfied by the indicator cards secured from blast furnace gas I had synthesised that the proposal was rationally scientific, and but for Sir Lowthian's illness the system would have been put in operation at the Clarence Works, Middlesboro'.

Mr. James Riley, Vice-President of the Iron and Steel Institute, determined with the good will of the Glasgow Iron Company to permit the invention to be tested at Wishaw, Scotland. I may here explain that there was only one engine driving the electric plant for the whole of these works. It was therefore rather a bold experiment, and had it failed, of course, they would have had to revert to the old oil lamps. I was, however, so confident of success that I risked the removal of the steam engine then driving the electrical machinery of the works, and in its place I put down a gas engine which was harnessed to my gas preparatory treatment apparatus. The result of the first few revolutions justified my confidence, and few modifications in the compression and igniting gear were necessary. I may explain to you that some of these alterations in the ignition gear were effected by Professor Rowden, who was of great service to me at the time. With these alterations the system was satisfactorily perfected, and with rare intermissions the engine has run nightly ever since. In 1896 I received a letter from Mr. Riley, in which he stated that the system had fulfilled all that was promised and hoped for. In these works the power is transmitted to a direct current machine, driving arc and incandescent lamps.

14493. What is the power of this gas engine?—It is very small, it is about 30 h.p. They do not require very much power at these works.

14494. (*Professor Dixon.*) What is the diameter of the cylinder?—I think it is about 12in.

14495. I only want it roughly?—I am speaking from memory.

I then demonstrated the value of the system in England applied to gas of exceptional thermal poverty, issuing from the Frodingham furnaces. This gas had occasionally only some 20 per cent. of carbon-monoxide, representing its thermal value plus 1 per cent. hydrogen. In 1897 I received a report from the managers stating that the experiment they had made was very satisfactory indeed, and that they were prepared to give the process a practical trial on a large scale.

Afterwards the value of the system was demonstrated by me on the Continent. In 1897 a pioneer plant was installed near Essen, Germany. This pioneer installation, after lengthened and exhaustive tests, was subsequently extended, as far as the treatment plant is concerned, to 4,000 h.p. The system has now been adopted very extensively all over Germany and Belgium, and German and Belgian engine builders have installed the system in Austria and Russia.

14496. (*Sir George Armytage.*) You say this plant near Essen was extended to 4,000 h.p. Do you mean 4,000 h.p. at one place?—Yes, in one installation.

14497. How many engines?—I am speaking now of the treatment plant. There are already two engines installed of 1,000 h.p. each.

14498. (*Professor Dixon.*) Is the treatment plant practically to get rid of the tar?—No, principally the dust. (*The Witness produced photographs.*) This photograph shows the engine-house and the cooling tank. This plant is intended for producing calcium carbide, and it has been producing calcium carbide, and it is intended for power and light purposes as well.

14499. (*Mr. Briggs.*) It is not for blowing blast furnaces?—They have that idea, of course. They had just installed some new steam engines at the date of my introduction of the system into Germany, but they intend to adapt it entirely to all their power purposes. They are receiving an excellent price for the power they are supplying, and therefore they are satisfied.

14500. It is a commercial business?—Yes.

Various estimates of the aggregate horse-power installed in Germany alone have been proffered by different authorities—some give the figures as 170,000 i.h.p., and

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others give figures of much less magnitude. However, it is estimated that the economy that Germany will secure, when the system is applied to its utmost limits, will provide an immense coal saving, financially estimated at several millions of marks. As the iron output of Germany is fast approaching that of Great Britain, the figures for our own country, given further on, can be taken for the former country, allowing a reduction of 20 per cent. for the higher average thermal efficiency of the German furnaces.

American engineers and scientists are now thoroughly alive to the economic possibilities of the system, and Professor Richards states that in one new ironworks projected some 40,000 i.h.p. will be ultimately installed.

Before the year 1894 gas-engine builders had made several attempts to increase the power capacity of producer gas-engines, using one or other of the several kinds of producer gases in the market; these gases possessed the common characteristic of a high (relatively) proportion of hydrogen, and generally some hydro-carbons, their thermal value rarely being less than 150 British thermal units per cubic foot, against say 100 British thermal units, the average representative thermal value of blast-furnace gas.

The general impression at the time was that hydrogen in considerable percentage proportion was an absolutely essential part of an ideal power gas, indeed one expert still adheres to the view, *e.g.*, that the ideal power gas should never have a less calorific value than is represented by 1,200 calories per cubic metre, or 135 British thermal units per cubic foot. By reference to the Journal of the Iron and Steel Institute, No. 11 for 1901, you will see particular reference made to this view. It was said that the ideal power gas should not contain less than 15 per cent. of hydrogen, and gas-engine builders accepted this view, and producer gases, with the characteristics mentioned, were harnessed to gas-engines of power capacities varying from 50 to 150 h.p., which were installed for driving electric generating machinery at Morecambe, King's Lynn, and Leyton.

All these producer gas-engine installations had eventually to be removed, and it is certain that but for the success of the blast-furnace pioneer installations the expansion of the power capacity of internal combustion engines would have been set back perhaps for many years.

The advantages of the blast-furnace gas, and especially the power it gives of control over the character of the expansion curve, soon convinced German and Belgian gas-engine builders that they could with confidence venture to build gas-engines of a 1,000 i.h.p. capacity; and this power potential has been extended, and responsible gas-engine builders can be found to-day who would not hesitate to build engines of a single unit multiple cylinder capacity of 2,500 i.h.p. Certainly the thermal efficiency of the blast-furnace gas-engine, especially after the year 1900, would have given great delight to Carnot, Rankine, Clerk-Maxwell and Joule.

The thermal and every-day efficiency of an ordinarily good steam engine and steam boiler, even if under competent supervision, rarely exceeds 5 to 10 per cent. But the thermal efficiency of a blast-furnace gas-engine working under every-day working conditions is never less than 20 per cent., and is usually much higher than this; in large capacity engines it has reached 30 per cent., and the average thermal efficiency is 25 per cent. Allowing for the increase of specific heat with temperatures even this high efficiency is not fairly representative of the actual thermal proportion. Details of a thermal test of an English plant during working conditions are given in the papers I have produced. I need not refer to them now, but, as a matter of fact, the tests made at the Sheepbridge Ironworks with an every-day running engine, which has been running over three years day by day, commencing early on Monday morning and going right on to Saturday night, and only stopping for an hour or two on Sundays, give wonderful results.

14501. (*Mr. Briggs.*) What is the Sheepbridge engine used for; it is not for blowing?—No, it is for power and light. It is driving all the electrical machinery for power. They have large foundries.

14502. (*Sir George Armytage.*) Where are the particular works you are speaking of?—The Sheepbridge Coal and Iron Company, Chesterfield.

Again, and for reasons already explained, the turning energy is so uniformly satisfactory that gas-engine builders are now prepared to guarantee under penalty a perfect cyclical regularity; less than a quarter of 1 per cent. I can get that guarantee from Messrs. Crossley Brothers.

The thermal efficiency of the gas-engines is almost independent of sustained supervising skill; once the conditions to secure the best proportion of air are fixed and the final density of the explosive mixture prior to ignition is properly determined, then the thermal efficiency will be constantly maintained, and the labour required is confined to securing the maintenance of the structural integrity and tightness of the machine and its proper lubrication.

The system is practically independent of a constant new water supply. Given a tank for jacket water circulation service (and an atmospheric water cooling tower in the absence of an economiser), then the water can be used over and over again. You will remember the stormy weather of November, 1901; is was very severe weather, and in fact all the telegraph poles were blown down in the Midlands. At that time, when the steam boilers were working either badly or not at all, owing to the effect of the cold weather storm on the chimney shafts, the blast-furnace gas-engines kept on working steadily throughout and without the least loss of efficiency; and scores of times, when the blast-furnace gas, owing to defective working of furnaces, has proved to be non-inflammable in the combustion chambers of the steam boiler, the gas has fired without a miss in the gas-engines.

I have explained to you already that this gas is so poor in value that at atmospheric pressure it will sometimes fail to ignite at all, but immediately you compress it up to 120lbs. you increase the density of the gas, and its thermal value is increased *pro rata*.

14503. (*Mr. Briggs.*) Does the pressure take place in the back stroke of the cylinder?—Yes, you compress the gas and air; in fact, the volume of air is only one to one; that is to say, there is one volume of gas and one volume of air, and when you get these into the cylinder you compress them to 120lbs.

14504. There is a loss in that compression?—There is, but you get it back again. We only lose from 5 to 10 per cent. at the maximum.

14505. You get it back on the return stroke?—Yes. Firing with ordinary gas, that is, very poor gas in the ordinary steam boilers and even stoves, if the draught is altered at all, the gas flame immediately goes out. But in our case we have always a constant supply of air; we mix the gas and air together, and compress them, and that explains all the difference between the control in firing by our system and that of gas at atmospheric pressure in boilers. Where the fire has to rely upon the chimney draught and air, and if the draught is varied by the influence of temperature and the influence of wind, then, of course, you have failure. That occurs every day.

Again, the system is safety itself compared with steam generation accident possibilities. The papers produced contain a list of explosions which have occurred in blast furnace steam boilers. I do not remember a single instance of an accident through the unintentional explosion of blast furnace gas; besides the gas in passing through the treatment plant is only separated from the atmosphere by hydraulic seals, and the occurrence of an accidental explosion merely means the ejection of the water from the seal. The gas in passing through the elements of the preparatory plant is separated at various points, simply by hydraulic seals; there is a dip seal, which dips into water five or six inches, and we can scrape out any deposited material under this seal, so that if any explosion takes place all that it does is to drive out the water. It is a different matter in a boiler which is enclosed entirely by steel rivetted plates.

The preparatory treatment plant, known as the "static" system, is the acme of simplicity, and its durability is such that a two per cent. factor will adequately cover the depreciation. The percentage of depreciation is about similar to what you would provide for gas-holders. There is a gas-holder that has been worked from the very beginning of the introduction of gas lighting in Yorkshire, at Greetlands; it was put down, I think, in the forties, and I understand it is still working, or it was working not long ago. It is regularly covered with tar until it is

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Mr. Benjamin Howarth Thwaite.

30 April 1903.

about an inch thick. There is no appreciable pressure brought upon it, but it does its work; and that percentage of depreciation, namely, 2 %, equivalent to 60 years of efficient service, is applicable to all the plant associated with this process, so that you can say it is practically good for fifty years.

The magnificent progress of the system on the Continent, and its influence on the development of gas-engine power capacities would be thoroughly appreciated by all those who had the good fortune to visit the Düsseldorf Exposition of 1902. The *pièce de resistance* of this very fine exposition, constituting for most Englishmen a decided revelation, was the superb display of high-power capacity blast-furnace gas-engines, a display which will form a lasting monument to German scientific prescience and to German enterprise and engineering skill.

The difficulty met with in finding a gas-engine builder in the early years of the development of the new power system compelled me to undertake the preparation of designs myself, and with the help of my staff, fairly large power blast-furnace gas-engines have been built in England, and they have given great satisfaction. Blast-furnace gas-engines of large power capacity that embody in their designs the latest continental experience and cyclical perfections, may now be obtained in this country.

Amongst the makers are the following:—Crossley Bros., Limited, Manchester, Otto 4 cycle and tandem; Premier Company, Limited, Nottingham, Otto 4 cycle and tandem; Fraser and Chalmers, Limited, Erith, 2 cycle tandem; Mather and Platt, Limited, Manchester, 2 cycle tandem; Richardson, Westgarth and Company, Limited, Middlesborough, Otto 4 cycle tandem; British Westinghouse Company, Limited, Manchester, Otto 4 cycle tandem; Vickers-Maxim, Limited, Barrow, 2 cycle tandem; Willans and Robinson, Rugby, vertical Otto 4 cycle. In connection with Messrs. Vickers-Maxim and Company, I had a letter from Mr. Douglas Vickers to say that they are proposing to use the Oechelhauser system. Now the Oechelhauser system is one associated with the big German installation, photographs of which I have handed round. That is a 2 cycle system: but I am not absolutely sure that they intend proceeding with that arrangement. The system has been applied for generating electric light and power energy, for pumping, for driving blast engines, and for generating electric energy for electrolytic and electro-thermal processes, and for other purposes, of course; it is impossible to say how many applications are in use, because it is being used for all power purposes.

14506. (*Sir George Armytage.*) The next subject you will deal with is the national importance of the blast-furnace power system in saving coal. That is a matter which is more important to us; but I would suggest that any questions which it is desired to put upon the first portion of your evidence had better be put now, and then we can deal with the other part?—Yes.

14507. (*Professor Dixon.*) What do you mean by "the sensitiveness of hydrogen"?—Hydrogen, when it is fired in an ordinary gas flame, as you know, is the first to burn—you have the blue flame; it is more sensitive than carbonic-oxide or the other hydro-carbons.

14508. Do you mean it is more easily ignited?—It ignites more easily; it has a greater preference for oxygen. If we have an ordinary carbonic-oxide combustible and we introduce 2 per cent. of hydrogen, we have immediately a more rapid firing effect shown on the indicator card.

14509. The flame goes more quickly through it?—It fires more quickly.

14510. That is all you mean?—Yes.

14511. I should have thought it would be better to say "more rapid ignition"?—Yes. Well, I have used the word "sensitiveness."

14512. The term "oxygen agent" means the oxygen of the air necessary to burn it?—Yes, that is so.

14513. You only put a little excess of oxygen in, I suppose? You speak about equal volumes of air?—Well, we have just a little over the absolute chemical equivalence.

14514. What is the average percentage of carbon monoxide in the blast-furnace gas?—It is from 27 to 30 per cent.

14515. And you use about 21 volumes of oxygen with it?—Yes, practically about that; we use practically 1 of air to 1 of gas.

14516. Therefore, you use half as much oxygen again as is necessary to burn the carbon monoxide?—The ratio of excess is as 21 is to 14. We use equal volumes in al cases, practically. That is the ratio we use.

14517. You use an excess of oxygen?—Yes.

14518. I am, of course, speaking chemically now?—Yes.

14519. In summarising the advantages, I should like to ask you what is the meaning of the first one, namely, "After combustion only the thermal loss due to its sensible heat; no latent heat loss."—I explained that.

14520. It was not quite clear in the way in which you expressed it.—It is the latent heat effect.

14521. How does that come in?—I show it in this book. (*The Witness handed a book to Professor Dixon.*)

14522. I only want it quite generally?—It is due to the formation of water; we do not condense this gas, it always goes off hot; we do not recover the latent heat absorbed.

14523. And neither would you with the water, would you?—If hydrogen is ignited with oxygen, water is formed.

14524. Or rather steam is formed?—Yes, steam; and, of course, there is a loss due to latent heat, which does not occur with carbon monoxide.

14525. I do not follow that; what latent heat?—Due to the turning of the water into steam.

14526. But you begin by steam; you do not turn water into steam?—But you do not recover that heat.

14527. No, you do not recover it.—And it becomes a loss if you do not recover it. We do not condense the gases after combustion by bringing them down below a temperature of 212°. If we did that then we should recover the heat that is absorbed in the formation of steam.

14528. You begin by assuming that you will get all the heat out of the hydrogen, condensing the steam to water?—Yes.

14529. And then you say you do not get that, because there is no condensation?—That is it.

14530. I do not see where the advantage is that is claimed: I cannot see the point of that?—I have explained it by calculations which are contained in the book I have handed in.

14531. I think I see what you mean, but it was not quite evident?—Perhaps it would not be, but I had to give the facts in as brief a form as possible.

14532. Of course, what I am questioning is the statement that you have an advantage in burning carbonic oxide, because the only loss is due to its sensible heat. If you were burning hydrogen the loss would be due to its sensible heat, and the steam disappears?—Yes, but you have to oxidise that hydrogen, and in oxidising it to steam vapour you have a certain latent heat loss—you have an absorption of heat in the form of steam.

14533. No, I do not see that you have; you do not recover the heat again, it is true; you do not recover a certain quantity of heat which you could get if you condensed the steam. You apparently claim an advantage for carbon-monoxide over hydrogen, because when you burn the former there is no possibility of condensation, but when you burn the latter, it is possible to condense the steam formed. When both products of combustion in the two cases, viz:—carbonic acid and steam pass away, in the gaseous state, you lose "the latent heat" of both equally. Is not that so?—Well, we do not condense the steam.

14534. That is what I mean. You never get it in the form of water at all; it is steam when it is formed?—Yes, of course.

14535. Then I think you said the horse power of this engine, which you tried at Glasgow, was about 30?—Yes.

14536. What is the power of the largest gas engines that are now made—I mean in a single cylinder?—With a single cylinder, 750 kilowatts; that is, practically 1,500 h.p. When I say "a single cylinder," that is of the Oechelhauser type, the same as the Körting engine.

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14537. Mather and Platt are making the Körting engine, are they not?—Yes. I think they have just finished a 700 h.p. engine.

14538. I think it is 750?—Very likely that is so.

14539. (*Dr. Le Neve Foster.*) Do I understand you to say that you were the first person to use blast-furnace gas for internal combustion engines?—Yes.

14540. What is the main point of your invention that you speak of here, of May 1894?—The patent of 1894 was drawn up by a famous man named Hunt, of Glasgow, who is a Patent Agent there; he drew it up, and he arranged the patent in such a way that the harnessing of the gas engine, by a special preparatory plant for dealing with the blast-furnace gas and denuding it of all its moisture and its suspended matter, was made the subject of a master patent.

14541. Does it denude it of dust?—Yes, it denudes the gas of suspended matter in such a way that it is suitable for firing, and it is clean in the gas engine cylinder.

14542. That was the preparation of the gas for any internal gas engine?—That is so.

14543. But you say you were the first person to use blast furnace gas in internal combustion engines?—Yes, that is true.

14544. (*Professor Dixon.*) With regard to this photograph you have shown us, what installation is this?—This is at Borbeck, near Essen, in Germany.

14545. *Those* are something in the nature of scrubbers, I suppose. (*Referring to photograph*)?—Yes, that is part of the preparatory apparatus; you can call them "scrubbers" if you like.

14546. Do they actually go through water?—No, not in this particular process. We have hydraulic seals, as I explained to you, but we have no water.

14547. Is there any washing arrangement?—No washing at all; it is a dry cleaning process.

14548. Do you send the gas into a holder before using it?—Yes.

14549. I notice there is a holder shown in this photograph?—Yes.

14550. That is all that is done?—Yes, that is all.

14551. (*Mr. J. S. Dixon.*) I understand that you compress this gas in the first place?—Yes.

14552. Will you explain how that is done, generally?—Yes, the gas and air are both, by the movement of the piston, drawn together into the cylinder of the gas engine; then the valves are absolutely closed by mechanical arrangements, and the compressed gas and air mixture cannot escape; then the piston gradually returns, the pressure increasing all the time until you get 120lbs., before the mixture is even allowed to come into contact with the igniting arrangement which fires the gas. When it gets to 120lbs. pressure, then the valve is opened and an electrical jet—we will speak of it as a jet—an electrical lighting arrangement, or a jet, or heated tube, fires the combustible mixture.

14553. It is done automatically by the engine itself?—Yes. Then, of course, we get back the compression energy on the return piston stroke. There is a certain amount of mechanical loss when you compress gas up to 120lbs., but the compressed gas will force back the piston until it has expended its energy; so that we do not lose the energy due to compression; we lose a little by reason of friction.

14554. It is an essential part of the arrangement?—Absolutely essential.

14555. You made a remark about the higher thermal efficiency of gas in German furnaces. How does that compare with coal?—Well, they claim that the German furnace is a more perfect apparatus, and they maintain a more close analysis of the progress of the work as it goes on. I know that all the managers are men of scientific attainments.

14556. Do you speak of a gas or a coal or a coke furnace?—Generally coke.

14557. (*Mr. Briggs.*) When you speak of blast furnace gas generally, are you speaking of gas from coke furnaces?—Well, at Wishaw, in Scotland, it is entirely from coal furnaces.

14558. I know that practically all the Scotch furnaces, or the bulk of them, are coal furnaces?—That is so.

14559. Your treatment has not included the abstraction of the residuals from the coal gases, has it?—No, it has not; but at Sheepbridge the proportion of coal is about two-fifths, and some tar is recovered.

14560. In Scotland it would be 80 per cent.?—Yes. As a matter of fact the process of condensation associated with the ammonia recovery plant of Scottish furnaces by reducing the temperature brings down water and with it the tar, and the tar and water run away in the open seals and are there separated.

14561. Of course, in Scotland, if not your system, at any rate something very similar has been adopted for at least 12 or 15 years?—Yes; you are speaking of the ammonia plant.

14562. That in itself purifies the gas?—No, unfortunately, it does not, and I will tell you why; we tried it at Wishaw by taking the effluent gas from this ammonia recovery plant—we tried the gas after passing through this treatment of ammonia and tar recovery—and we found the engine got clogged with dirt and tar; it failed.

14563. Therefore you hold that it would require additional treatment?—Yes.

14564. But still that gas, so scrubbed and cleaned, would be of equal efficiency to coke gas units for the production of power?—Oh, it is better than coke gas.

14565. It would have a higher proportion of carbon monoxide?—Certainly. It is a better gas thermally, and it has a higher proportion of carbon monoxide.

14566. There is another point which you made that in the quick explosive gases the effect is bad, inasmuch as it is at the very commencement of the stroke. But do they not do something to retard the ignition and get over that?—Well, you see it is so sensitive that it would be impossible to retard it to the same extent as less sensitive gas.

14567. Could you not retard it by mechanical ignition?—We have tried to do that with all our power gas plants and we cannot do it.

14568. So that you found it impossible by retarding the ignition to make up for that disadvantage?—That is so.

14569. (*Sir George Armytage.*) I suppose the producer gas would act the same as blast furnace gas?—No, that is precisely the point. I have worked producer gas with Crossley Brothers and others since 1885, I think, and, although I have succeeded fairly well, the gas which I have produced, which is now being made in America by Loomis Pettibone, is not equal to the blast furnace gas; the blast furnace gas is absolutely ideal for the purpose.

14570. What do you mean by "not equal"?—Not equal for practical purposes.

14571. But still, they do work large engines by producer gas?—Yes, I have worked them, and power gas plants have been in existence for many years up to 300 horse power. I am speaking, however, of a gas having the essentials of uniform calorific value to secure regular pressure cards and to permit the gas engines to drive alternating types of electrical generators.

14572. Is there a great deal of difference in the value and effect of producer gas as compared with blast furnace gas?—Yes, there is a considerable difference in work; the latter works so steadily and uniformly and gives no trouble, and the other is so variable; the gas produced from producers even of the best type is so variable in quality that you cannot rely upon it for driving machinery which requires more or less cyclical satisfactory regularity. It will serve for driving pumping machinery.

14573. (*Mr. J. S. Dixon.*) Do you prefer the gas from furnaces to the richer gas from producers?—Yes, very much so, there is no comparison.

(*Mr. J. S. Dixon.*) I thought it was the other way about.

14574. (*Sir Lindsay Wood.*) Then you can only use blast furnace gas somewhere at or near blast furnaces?—Yes, that is so. The question which I have just answered leads to the point of the possibility of the area being extended by imitating this gas.

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Mr. Benjamin Howarth Thwaite.

30 April 1903.

14575. Only to a small extent?—I think to a very considerable extent. I am trying to explain now that we are going to make this blast furnace gas without making the iron.

14576. That would be nearly the same as producer gas?—No, it is distinct.

14577. (*Sir George Armytage.*) You think we shall probably hear some more about this?—Yes, it is only in an experimental stage.

14578. (*Professor Dixon.*) I have read through the part of your book to which you referred me; you have given the total heat of combustion of hydrogen to liquid water, viz.—68,000 calories for 2 grains of hydrogen burnt?—Yes.

14579. Then, of course, you take off the 10,000 calories due to the steam condensing afterwards?—Yes.

14580. And that was the saving of burning carbonic oxide?—Yes—you have it now.

14581. There is one question I should like to put to you concerning the mode of combustion of gases, which is this: have you ever made a mixture of any hydro-carbon, say marsh gas, with air or oxygen (with only enough oxygen to burn, say, the carbon alone), and fired it?—No, I have never tried that experiment.

14582. You do not know, as a matter of fact, that the carbon burns before the hydrogen?—We know that in all ordinary gas burners the hydrogen is burning before the carbon.

14583. If you make a mixture of the gases (I am speaking of explosions in a gas cylinder), you still find that the carbon burns first?—I see the point you make. I have not made that test; and the reason I spoke about the hydrogen is that introducing it has at once a wonderful effect upon the combustion.

14584. The ignition is much quicker?—Yes.

14585. But you say that in the hydro-carbon the hydrogen burns first?—Yes, I think it does—that is, in open burners of course.

14586. But we are speaking, of course, of combustion in a gas cylinder from an explosion?—I think, logically, we can assume it is so. You have not any reason for thinking the reverse, have you?

14587. Yes, I have reasons for thinking that the reverse is true.—I am not prepared to speak with regard to that. I am very much surprised all the same.

14588. (*Sir George Armytage.*) Now we will come to the second part of your evidence, if you please.—That is as to the national importance of the blast furnace gas power system in saving coal. The thermal efficiency superiority over the system of generating power by steam generally in use in our British ironworks—neglecting its safety advantages smokelessness, and practical independence of a continuous water supply—will be understood from the following example:—the thermal efficiency of the steam engine at one Belgian ironworks, with steam boilers fired with unpurified blast furnace gas, has been estimated to equal only 2·5 per cent., or only one-tenth, that of the purified blast furnace power gas-engine system. Other computations place the rates at a higher level, and the generally accepted figure is that the thermal efficiency of ironworks steam power plants is only one-fifth that of the internal combustion engine.

Everyone who has studied the new system admits that the fuel saving that will follow the utilisation of the system, even in a modified degree, makes it of national importance. The President of the Iron and Steel Institute calculates that in Cleveland, Yorkshire, there is in the blast furnaces of this district alone a constant gas waste equivalent to 60,000 i.h.p. per annum. Taking 3 lbs. per horse-power hour this means a yearly loss of nearly three-quarters of a million tons of coal.

I would allocate the expenditure of the thermal assets represented by the blast furnace gas effluents as follows:—

	Per cent.
Heating the air blast (high efficiency stoves) -	22·5
Providing power for blast furnace, blowing equipment, pump hoist, etc. - - -	9·0
Waste - - - - - - - -	10·0
Balance available for external power demand -	58·5
	100·0

Taking as the basis of calculation a blast furnace producing 100 tons of iron per day of 24 hours, and assuming that one ton of coke fuel is expended per ton of pig-iron produced, and that 95 cubic feet of gas are used to develop one indicated horse-power hour, and that 150,000 cubic feet of combustible gas are produced per ton of fuel charged into the furnace, all these assumptions being justified by experience, then $\frac{150,000}{95} = 1,579$ i.h.p. will be available from each ton of fuel if all the gas could be diverted to purposes external to the furnace requirements; but we know that only 58·5 per cent. of the gas can thus be so diverted. $\frac{1,579 \times 58·5}{100} =$ 923 i.h.p. Therefore $\frac{923 \times 100}{24} = 3,845$ h.p. per hour that will thus be available if the conditions are completely and ideally satisfied from each furnace having a daily output of 100 tons of pig-iron.

Now, if we take the iron output of Great Britain to be represented by that for the year 1900, *i.e.*, 9,448,840 tons, and take 25 cwts. of fuel (coke) to the ton, to allow for the high figures of Scottish and some Midland furnaces, then the available power works out to 1,190,000 i.h.p. years. If the blast furnace gas now employed in stoves is also diverted for power purposes (by firing the hot blast stoves with producer gas), then the aggregate potential power is increased to 1,457,000 h.p. I explained the theory of diverting the whole of the gas now used in stoves for power purposes and using common producer gas, such as we produce in Siemen's producers for firing the stoves, in my paper upon "The Profitable Utilisation of Power from Blast Furnace Gases" in the Journal of the Iron and Steel Institute, No. II., for 1901. This will, of course, increase the proportion of gas available for power purposes.

14589. (*Mr. Briggs.*) You will have to burn fuel to do that?—Yes.

14590. Would you do it any cheaper in that way? You have the apparatus to provide?—Well, I have gone into that question too, and I am giving you the conclusions I have arrived at. I do not rely upon this additional power you will notice, because I say assuming that this power potential was fully utilised in displacing steam power consuming say 3 lbs. per indicated horse power, then this displacement would mean a national saving of $\frac{1,190,000 \times 8,670 \times 3}{2,240} = 13,820,000$ tons of coal; and this neglects the saving that might be secured by diverting the gas from the stoves. You see I have taken it in that way. Estimating the value of this coal at 6s. 6d. delivered at the generating station this annual economy is represented in financial terms by £4,991,500. We can test this figure as follows: Assuming the value of the fuel *per se* to develop one indicated horse power year to be £3 15s.—neglecting the saving in labour, water, depreciation, and insurance—this equals the sum of £4,462,500. Even if this figure of financial economy is divided by half, representing £2,231,250, that, capitalised at 5 per cent., would mean that the waste of fuel would justify a capital expenditure of £44,625,000 sterling on plant for utilising the gas to produce power in internal combustion engines, whereby this waste would be prevented.

Some of our iron experts are asserting that the future of the inland iron-works in Great Britain is very dark, and that the works must either be removed to the sea coast, or suffer inevitable extinction under the severe competition with which this country is faced. Now, it would be possible to recover from these inland blast furnaces a dynamic power potential of some 430,000 indicated horse power, and this power should have an annual value of £806,250, and this profit would alone justify the expenditure that could be wisely incurred in modernising these inland blast furnaces.

The advantage possessed by Great Britain as an iron manufacturing country is the fact that the inland British and Scotch blast furnaces are actually located either near to or in the very midst of the manufacturing industrial areas, and that by the application of electrical methods of transformation and distribution the power potential of the blast furnaces could be profitably distributed to the factories within a radius of 25 miles. The removal of the inland ironworks to the sea-coast

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would destroy some of the advantages to be secured by the sale of the power potential; besides the inland blast furnaces are well placed in relation to the coal and flux supply, and this advantage would be partially destroyed by the removal of the iron furnaces away from industrial centres. The one drawback, high railway rates, will be removed in due course, and especially when the railways and canals are electrified.

If the owners of British inland blast furnaces take full advantage of the power potential of their now wasted power gases, there need be little fear of the complete extinction that is threatened by foreign competition. Calculation will show that if only half the total amount given as the financial saving is secured, this will mean a return from the sale of power potential equivalent to 4s. 7d. per ton of iron made. This financial advantage is sufficiently substantial to justify the policy of the owners of inland blast furnaces in insisting that in all electric power transmission schemes the power potential of their furnaces, at a reasonable rate to be determined, shall be utilised in generating the electric energy.

As I pointed out in my contribution to the discussion in Mordey and Jenkins' paper on Electric Traction on Railways, read at the Institution of Civil Engineers on 13th February, 1902, there are a considerable number of blast furnaces located near our trunk railways, the Midland Railway Company being specially favoured in this way. These furnaces would supply a considerable proportion of the power potential that would be required to satisfy the electrical requirements of the railways on their electrification. That blast furnaces are located in well-placed positions for the satisfaction of the supply of power energy for electric power supply areas is practically shown in the plan which I now produce, on which are marked the possibilities of the furnaces in different iron producing centres in Great Britain. (*The Witness handed in copies of plan.*)

Supplement, Plate 19.

14591. (*Sir George Armytage.*) Then you suggest that taking these groups of blast furnaces as your centres you would be able to supply the power to a radius of 25 miles around each centre?—Yes.

14592. What loss do you anticipate from carrying your gas that distance?—I do not propose to send the gas; I propose to transform it into electricity and send it under high tension.

14593. You propose to make it into electricity at the station?—Yes.

15594. And then to send the electrical power?—That is so.

14595. It would be rather difficult to get all these people into one mind, would it not?—I know of one power Bill before the Houses of Parliament at least, if not two, in which clauses have been inserted (I think it is the Derby and Nottingham) that if possible blast-furnace gas shall be utilised for power purposes.

14596. Then calculating right through from the point of starting to the delivery of the electricity at 25 miles distance, what comparison do you make and what saving do you show on present methods of working by steam engine?—This gas itself is practically a waste product.

14597. It is to-day, we will say?—Yes, it is practically a waste product. Of course, I can only answer that question which you ask by referring to the fact that it entirely depends upon the arrangements made between the consumers of power, say the Electrical Supply Company, and the blast furnace owner. He can supply it for nothing if he likes, and can give it away.

14598. You would have to get a number of men to agree together to associate themselves with the blast furnace people and to form, as it were, a company for the supply of the power within this area, would you not?—Yes, of course, supposing we have a particular scheme, say a power scheme, the promoters can go to the owners of the furnaces in the neighbourhood and say, "Now, gentlemen, what price will you charge for guaranteeing a supply of your gas to our engines for a year," and upon that, of course, depends the economy. If the price is high it is out of the question.

14599. They would have to put up the apparatus for collecting the gas from the furnaces?—Yes; they might simply take the gas away from the furnaces. It is practically like a water-fall, if it is running away they can tap it.

14600. The apparatus would not take up much room?—No, nothing serious.

14601. You would require no gas-holder?—Yes, we should require a gas-holder to establish a uniform pressure on the gas before it is delivered to the engine. Supposing you are an ironmaster, and I come to you, wishing to obtain power from you, and I say, "I will take the gas away from your conduits—from your furnace."

14602. Could you make it into electricity on the spot?—Yes, at once, on the spot. I say, "If you will give me your gas I will pay you so much per kilowatt year shown upon my instrument." You say, "Very well, you take it; as long as you do not interfere with my furnaces I will give it to you," and you, on the other hand, guarantee that the supply shall be constant.

14603. (*Professor Dixon.*) Could you tell us roughly the cost of the installation which would be necessary, say, for plant where they are making 100 tons of iron per day? That is what you have taken as the basis in your calculation here?—You may multiply it by £10. We have 3,845 h.p., and you multiply that by £10, which will give you your plant.

14604. Roughly £40,000?—Yes.

14605. (*Sir George Armytage.*) But 3,845 h.p. would not go very far on a radius of 25 miles, would it?—You do not lose much by electrical transformation. You might lose by high tension purposes, say 15 per cent.

14606. But the quantity would hardly be sufficient, would it?—That is only the output of one small furnace.

14607. (*Professor Dixon.*) I only took that as a calculation. That, I suppose, you would put as the lowest limit at which it would be feasible to work?—Yes, that is not a big furnace.

14608. The greater the number of furnaces—the greater the amount of power.

14609. (*Sir George Armytage.*) What you mean is that for each furnace with 100 tons daily output at an ironworks you would require £38,000 for the plant?—Yes.

14610. That is the proportionate amount?—Yes; and you have 3,845 h.p. from one furnace for 100 tons.

14611. (*Professor Dixon.*) The bigger the iron-works the more economical on the whole the making of the gas would be?—That is so.

14612. With the purified blast-furnace gas according to your system you would not have practically any possibility of self-ignition?—No, none whatever.

14613. (*Dr. Le Neve Foster.*) I gather your view is that you would look upon the blast furnace in the future as a great gas producer for internal combustion engines?—Yes.

14614. And the pig-iron as a bye-product?—Most decidedly.

14615-17. Could you not get some gas from coking plants as well as from blast furnaces? I mean why should you not take that into consideration?—As a matter of fact that has been taken into consideration.

14618. (*Mr. J. S. Dixon.*) You have demonstrated or put before us a very large saving in coal by the utilisation of these gases in the way you desire, which is a very material point to our inquiry here?—Yes.

14619. But can you explain why so little progress is made with its adoption?—That is a very, very big question. Ironmasters here are rather frightened. In Germany I have no difficulty; they seem to understand the principle and the possible economies of the new system at once, and I have no difficulty in explaining to them; they seemed to understand it as well as I did, and they had more confidence in proceeding—they are so much further ahead. On the other hand, we had some difficulty here by reason of this, which it is only fair to the ironmasters to mention, that the first contractor who made engines for this purpose made an engine which was not a success from the point of view of construction. It was a success from every other point of view, but it was not sufficiently strongly built, and that misfortune, no doubt, had some deterring effect. But at the same time in view of these large successes in Germany they might easily have been satisfied.

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Mr. Benjamin Howarth Thwaite.

30 April 1903.

14620. There is a case which I can put before you at the present moment. You mentioned the Westinghouse Company as makers of these gas-engines?—Yes.

14621. Near Glasgow, where I come from, they are putting down a large electric plant for the transmission of power—Yes, and they are close to the blast furnaces.

14622. One power station is about a mile from the Wishaw blast furnaces that you mentioned, and they are not only not going to utilise the furnace gas, but they are not going to put up a gas plant at all; they are going to drive the installation by steam?—As a matter of fact they are taking into serious consideration the question of putting very large gas engines down at the very moment.

14623. Since I have come here and heard about gas-engines, and that the Westinghouse people are making them, I have not been able to understand how it is that they are not putting them down in that way now?—I think I can explain that to you; they have not got a gas-engine yet which is absolutely reliable for use with blast furnace gas; they have under consideration and are building experimental gas-engines, but that is a different thing from taking a contract and commencing to put them down for public electric light and power supply.

14624. It is a very good chance to such a company to put down producers and gas plant, and to abandon steam altogether. I have remarked to some of my neighbours that I do not understand why they are not doing it, having regard to the evidence I have heard upon this Commission?—Well, I think that is the explanation; they are nevertheless most seriously interested in the new power system.

14625. (*Sir George Armytage.*) It takes some time for people to have confidence in new inventions, does it not?—The progress is going to be very rapid now. All the makers are seriously at work, every one of them.

14626. (*Mr. J. S. Dixon.*) I think that installation I have referred to will in five years' time be behind the age?—Yes, I am quite sure it will be.

14627. (*Mr. Briggs.*) You mentioned Frodingham as a place at which you had had a successful experiment?—Yes.

14628. Have they taken any steps towards altering their furnaces now?—Yes, they have ordered a 750 h.p. engine.

14629. That is the Frodingham Iron and Steel Company?—Yes.

14630. So that they are going to commence?—Yes.

14631. Is there not this difficulty at present, that all blast furnace firms who have not got gas engines for the production of power, consume the whole of their gas at the present moment in raising steam at their places?—You mean they are wasting it?

14632. That is a question; but at present they have not any surplus to sell; if they sold it they would have immediately to burn coal under their boilers, that is to say, with their present plant?—That is so in some instances.

14633. So that it follows that they would first have to be satisfied that gas engines would do their work, and supply all their power at their place besides heating their stoves, and that they would have to have a surplus before they could go to somebody outside?—Yes, that is true. That is a very important question, which enables me to explain something.

14634. That is the very difficulty, is it not? I am interested in an electrical works, and we should be very glad to get blast furnace gas at a very low rate, or for nothing if we could; but so far the blast furnace people want all their gas?—I can explain that to you. I have here a photograph of a gas engine at the Claycross Ironworks, which is placed alongside the steam boilers; sometimes they have not been able to get the steam at all for their present engines. As a matter of fact, we have worked that gas engine, which will develop 300 h.p., and we could easily have got up to 500 h.p.; the gas it uses does not interfere in the least with the supply for the steam boilers; the economy is so great, and the expenditure of gas is so small, that they do not feel it.

14635. I am quite persuaded that you are right, and that it is much more economical; but the great difficulty which stands in the way of electrical power people taking this blast furnace gas is that people say they want all their blast furnace gas, and that is the fact?—But supposing now they are using 3,000 h.p. in their boilers for their engines; you multiply that by four, which makes 12,000 h.p., and deducting 3,000 from 12,000, you have 9,000 h.p. to give away, and you get the power all the same.

14636. You mean to say that your method of using up the gas would be four times as economical as burning it under a boiler and turning it into steam?—Yes.

14637. Then it does come back to this, that the first great point is to convert the blast furnace people to this, that as soon as they have a surplus of gas they should sell it to people who wish to use it?—Yes. The Yorkshire Iron Company are putting down a Cockerill engine of 750 h.p. for blowing purposes, and they will at once realise four times that power for sale; that is practically what it means.

14638. Yes, I gather that.—That is to say, four times 750, namely, 3,000 h.p.

14639. May I ask you if you have done anything at the Leeds Steel Works?—Mr. Richards is waiting for an opportunity to apply the system.

14640. (*Sir George Armytage.*) Do you say you are putting down an engine of 750 h.p.?—Westgarth and Richardsons are putting down a Cockerill engine of 750 i.h.p. to work my Blast Furnace Gas Treatment plant at Ardsley.

14641. For drawing purposes?—No, for blowing purposes. When they are working they will have practically four times the equivalent power of that gas to spare; by displacing the steam engine and boilers they are saving that amount of power.

14642. (*Mr. Young.*) I was not clear whether you answered the question put to you by Professor Foster with regard to waste gases in coke ovens?—No, I did not perhaps answer it sufficiently for you, but the question raised by him has been already considered, and at the particular ironworks of the Yorkshire Iron Company they are going to use this coke oven gas for that power purpose, and two engines are being installed of 250 h.p. each, that is to say, 500 h.p. for using that particular gas.

14643. Will there be quite as much gas wasted, do you think, from the coke ovens as is being wasted in the blast furnaces?—Well, the gases are so distinct I do not think you can compare them. There is gas wasted, but it is not so good for power generation. Again, the gas from coke ovens is volatile gas, and unless they dilute it very much with blast furnace gas or its equivalent and bring down the proportion of hydrogen, say to 5 per cent., I should not think of using it.

14644. Therefore you could not get the power as economically from the coke ovens?—The gas would not be so suitable for electrical driving.

14645. And it could not be made suitable?—It could, by diluting it with the other purely carbonic-oxide gas; as long as you do not get more than 5 per cent. of hydrogen and hydro-carbons in your power gas it is fairly satisfactory. So that you would have to use this volatile gas from the coke ovens and mix it with an immense preponderance of gas from the blast furnace.

14646. And it would not be more costly, would it?—No. There are several proposals under serious consideration; for instance, that the coke oven gas shall be used for firing the hot blast stove I have been speaking about.

14647. (*Mr. Briggs.*) For heating?—For heating; it is ideal for heating purposes; and then all the blast furnace gas would be preserved for power purposes.

14648. (*Mr. Teall.*) I think you said you observed a little difference between the readiness with which this application was taken up in Germany and in England?—Yes, most decidedly.

14649-50-51. Do you think that difference is largely due to a different condition as regards technical education in the two countries?—Yes, I have found a vast difference in the way they approached, received, and absorbed ideas in connection with the subject.

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Mr. MICHAEL LONGRIDGE, called; and Examined.

14652. (*Sir George Armytage.*) Will you kindly tell us your qualifications?—I am a member of the Institution of Civil Engineers, and a member of the Council of the Institution of Mechanical Engineers, and a Master of Arts of Cambridge.

14653. Will you read us your statement?—I have been asked to give evidence with regard to the economies in consumption of coal consequent on the improvements in engines and boilers during the past 25 years. My experience has been almost entirely with stationary engines and boilers. In considering the improvements which have been made, I think it would be convenient to consider separately:—(*a*) Improvements in boilers, that is, in the generation of steam; (*b*) improvements in steam engines, that is, in the use of steam for power; and (*c*) improvements due to the substitution of gas engines, oil engines, or electric motors for steam engines.

Mr. Michael Longridge.

30 April 1903.

Improvements in Boilers.—It is a matter of practical experience that the water evaporated per lb. of coal is much higher in some types of boilers than in others. For instance, a Lancashire boiler working with an economiser will evaporate 8lbs. of water per lb. of coal, where a small vertical boiler fed with cold water will evaporate 4lbs. It is therefore desirable, in considering the question of evaporation, to try to ascertain the percentages of the various types of boiler in use 25 years ago and at the present time. Unfortunately, I have been unable in the time at my disposal to ascertain the percentages in 1878. But in the year 1886, I made an analysis of 12,000 of the boilers then under the inspection of my company, and for the purpose of this inquiry I have caused to be made a similar analysis of 12,000 of the boilers under my inspection in 1903. The following Table shows the percentages by which the various types of boiler were represented at the two periods —

TABLE I.

TYPE OF BOILER.	1886.		1903.	
	Nos.	*Per Cent.*	*Nos.*	*Per Cent.*
a. Lancashire, Galloway, Marine and other large internally-fired boilers.	5,321	44·3	5,375	44·7
b. Cornish	2,710	22·6	2,170	18·2
c. Vertical with internal fire-box	1,821	15·2	2,410	20·0
d. Plain cylindrical	1,451	12·1	424	3·5
e. Portable and locomotive	433	3·6	1,174	9·8
f. Watertube	—	—	183	1·6
g. Miscellaneous	264	2·2	264	2·2
Total	12,000	100·0	12,000	100.0

Of these I should call type *a* generally economical; types *b*, *e*, *f*, *g*, moderately economical; types *c*, *d*, generally wasteful.

Before drawing any conclusion from these figures, it is necessary to explain that in 1886, and to a still greater extent in 1878, a far larger proportion of the small boilers (principally vertical and portable boilers) in use were worked without inspection than in 1903, so that the percentages given in the table for the year 1886, are not nearly so representative of the boilers in use at that time as the percentages for 1903 are for the boilers in use now. To make them representative it would be necessary to reduce the percentage (44·3) of the larger and more economical, internally-fired boilers, and to increase the percentages, 15·2 and 3·6, of the less economical vertical and portable types. If such corrections be made, I think the figures may be taken as fairly representative of the boilers in use at the two dates. If this be true, the figures clearly indicate that comparing the boilers now in use with those in use 17 years ago, and still more, 25 years ago, the proportion of the more wasteful boilers, especially of plain, cylindrical boilers, has been materially reduced. In my opinion the change has been principally due (1) to the replacement of plain, cylindrical boilers at collieries, blast furnaces, and brickworks by Lancashire or similar boilers; and (2) to the substitution of gas and oil engines for small steam engines. In estimating the extent to which this improvement in type has affected coal consumption, it is necessary to consider the average fire-grate areas of the various types of boilers, so as to estimate their relative importance as coal consumers. I think a rough estimate may be made by taking the grate area of class (*a*) at 30 square feet in 1886, and 33 square feet in 1903; of class (*b*), at 15 square feet; of class (*c*), at 7 square feet; of class (*d*), at 20 square feet; of class (*e*), at 6 square feet; of class (*f*), at 30 square feet; and class (*g*), at 10 square feet. Multiplying the numbers of boilers of each type in Table I by those grate areas, gives the aggregate grate areas of the different types of boiler in use in 1886 and 1903 as under:—

TABLE II.

TYPES OF BOILERS IN USE.	1886.		1903.	
	Aggregate Areas.	—	Aggregate Areas.	—
	Sq. Ft.	*Per Cent.*	*Sq. Ft.*	*Per Cent.*
a. Lancashire, Galloway, &c.	159,630	64·8	177,000	71·0
b. Cornish	40,700	16·2	32,550	12·6
c. Vertical with internal fire-box	12,747	5·1	16,870	6·7
d. Plain cylindrical	29,020	11·8	8,480	3·4
e. Portable and Locomotive	2,598	1·0	7,044	3·0
f. Watertube	—	—	5,490	2·2
g. Miscellaneous	2,640	1·1	2,640	1·1
TOTAL	247,335	100·0	250,074	100·0

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Mr. Michael Longridge.

30 April 1903.

Assuming the coal burnt to be roughly proportional to the grate areas this Table shows that much the largest proportion of the coal burnt in or under stationary boilers is burnt in boilers of the more economical types both in 1886 and in 1903. Therefore, I think that although there has been a considerable saving at collieries and among small steam users, yet, taking the country all round, I fear the average evaporation per lb. of coal is but little higher than it was 25 years ago. To give a clearer idea of the probable amount of this saving I will assume that the economical boilers of class (*a*) will evaporate 8 lbs. of water per lb. of coal; the moderately economical boilers of classes *b*, *e*, *f*, *g*, 6lbs.; and the wasteful classes, *c*, *d*, 4lbs. Multiplying the percentages in Table II. by these figures the water evaporated by 100lbs. of coal would be as under:—

1886.

a. Economical boilers	-	64·8 × 8 =	518·4
b., *e*., *f*., *g*. Moderate boilers	-	18·3 × 6 =	109·8
c., *d*. Wasteful boilers	-	16·9 × 4 =	67·6
			695·8

1903.

a. Economical boilers	-	71·0 × 8 =	568
b., *e*., *f*., *g*. Moderate boilers	-	18·9 × 6 =	113·4
c., *d*. Wasteful boilers	-	10·1 × 4 =	40·4
			721·8

a general saving of 26lbs. on 695·8 or 3·75 per cent. The real saving is probably greater, owing partly to the boilers in use in 1886 being on the whole of better types than those in use in 1879, and partly to the increase in the size of the larger and more economical type of boiler in which the greatest part of the coal was burnt, also to greater interest in coal consumption owing to increase in the price of fuel; but I do not think that on the whole the water evaporated per lb. of coal in 1903 exceeds that evaporated in 1878 by 7½ per cent.

Improvements in Steam Engines.—To a very large extent, the saving in steam used per horse-power per hour may be gauged by the increase in pressure during the period under consideration. In order to ascertain this increase roughly, I examined the registers of policies issued on boilers during the years 1879 and 1880, and during the years 1901 and 1902, with the following results:—

TABLE III.

YEAR.	Number of Boilers accepted for Insurance.	Average pressure, lbs. per square inch.
1879 and 1880 - - - - - - - -	2,878	52·3
1901 and 1902 - - - - - - - -	9,778	82·6

an average increase of 30·3lbs. Actually the increase had been greater than 30.3lbs., because on the one hand the owners of the small boilers which generally worked at low pressure did not insure to the same extent in 1879 as they did in 1901; and, on the other, because an unusually large number of such owners did insure in 1901–2 owing to the operation of the Boiler Explosions and Factory Acts. Thus the average pressure in 1879 was certainly below 50lbs., while the average pressure at the present time is above 82lbs. The latter statement is proved by the fact that the average pressure of the 12,000 boilers taken for analysis from among the boilers under inspection in 1903 is 88lbs. I do not think it would be far wrong to assume that the steam pressure has been practically doubled in the last 25 years, and that in consequence of the increase the steam consumption per horse power per hour has been reduced by about 33 per cent. I might perhaps mention that of the 12,000 boilers last referred to:—

2,930	= 24·4	per cent were working	between	0 and 50 lbs.
3,681	= 30·7	„	„	50 and 75 „
3,411	= 28·5	„	„	75 and 100 „
944	= 7·9	„	„	100 and 125 „
568	= 4·7	„	„	125 and 150 „
428	= 3·5	„	„	150 and 200 „
38	= 0·3	„	„	above 200 lbs.
12,000	100·0			

Unfortunately I have had no material for making a similar analysis of boilers working in 1879. To get some idea as to the relative importance of the improvements in boilers and steam engines, I have analysed the 12,000 boilers in the column headed 1903 in Table I., to show what proportion were engaged in different classes of trades. In some trades most of the steam raised was used for power; in others it was used partly for power and partly for heating water or other liquids; in others, again, almost entirely for heating. I may also point out that at blast furnaces and rolling mills the steam required is often raised from waste gases from furnaces.

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TABLE IV.

	Factories using boilers principally for power, *e.g.*, Textile Factories, Corn Mills, Rope Works, Tanneries, Boot Works, Electricity Works.	Factories using boilers partly for power and partly for heating and boiling water, *e.g.*, Print Works, Die Works, Bleach Works, Chemical Works, Paper Works.	Places using boilers almost entirely for heating, *e.g.*, Schools, Asylums, Hospitals, Laundries.	Factories using boilers for power when load is irregular, *e.g.*, Engineers' Shops, Shipyards.	Collieries and Brick works.	Blast Furnaces and Rolling Mills.	Small Steam Users, *e.g.*, Pork Butchers, Mineral Water Makers, Builders, Contractors, Joiners, Farms, Quarries.
(*a*) Lancashire, Galloway, Marine and other similar boilers.	2,490	948	195	594	590	55	503
(*b*) Cornish - - -	540	377	297	274	156	25	501
(*c*) Vertical and internal firebox.	180	149	302	376	108	24	1,271
(*d*) Plain cylindrical -	48	36	43	84	127	4	82
(*e*) Portable and locomotive.	66	80	83	151	142	19	633
(*f*) Watertube - -	54	6	36	71	3	5	8
(*g*) Miscellaneous - -	74	32	36	32	24	38	28
	3,452	1,628	992	1,582	1,150	170	3,026

Improvements due to the substitution of gas engines, oil engines, or electric motors for steam engines.—In small industries the small non-condensing engine, taking from 12 to 15lbs. of coal per horse power, is rapidly disappearing and giving place to gas or oil engines or to electric motors. The gas engines are usually worked with town gas, and take from 4½ to 5lbs. of coal per horse power. The oil engines use no coal. The electric motors are generally supplied from lighting stations. From the returns from 116 stations given in the "Electrical Times" for March, 1903, I find the average cost of coal per unit sold is 0·815d. Assuming the average price of coal to be 10s. per ton, 0·815d. would represent 15·2lbs. of coal, making the rate of consumption 11·3 lbs. per horse power per hour; that corresponds to 15·2lbs. per unit. Taking into account the low efficiencies of many of the small electric motors, it does not appear that they are more economical in coal than small steam engines; on the contrary, their introduction has probably led to increased coal consumption, because they are being put in in many places where power has not been used before. In works, as distinguished from small industries, gas engines are usually worked with producer gas made from anthracite, the average rate of consumption being about 1½lbs. per horse power per hour. These engines probably replace small condensing engines, or non-condensing engines of the better class, using from four to six pounds of coal per horse power per hour.

14654. Then on the whole you do not think that the improvement in the boilers is more than 7½ per cent. in those 25 years?—I feel pretty sure that it is considerably under that. I think that is the utmost limit you could place it at.

14655. But the improvement in the steam engine is equal to about 33 per cent.?—Yes, I should think that is so; it is very considerable.

14656. In regard to small engines your general opinion is that people are using oil and gas engines?—Yes, to a very large extent.

14657. Instead of putting in the extravagant ones that they had before?—That is so. I think that small steam engines will practically have disappeared in a very few years.

14658. Towards the latter part of your evidence you say: "In works as distinguished from small industries, gas engines are usually worked with producer gas made from anthracite, the average rate of consumption being about 1½lbs. per horse power per hour," that is to say, against the engines which use from 4 to 6lbs.?—Yes.

14659. So that in that case there is a very marked difference?—Yes, but then it is a peculiar kind of coal, you see. I have mentioned it particularly.

14660. But on the whole I gather you do not think that the use of electric energy is really causing very much economy?—Not in the small industries. Taking lighting stations, the load factor in a lighting station is so bad; of course, as the increase of power goes on, if more of these small industries would take the power from the lighting stations, the load factor would improve.

14661. That is, as you get larger installations and big power stations, and so forth?—Yes, as you get a greater day load, a greater motor load.

14662. (*Professor Dixon.*) You say in your statement: "The gas engines are usually worked with town gas, and take from 4½ to 5lbs. of coal per horse power;" I suppose you mean the coal burnt in the gas works?—In the gas works; I ascertained that the average quantity of gas produced from a ton of coal is about 10,000 to 11,000 cubic feet; and these gas engines, taking into account all the waste, will take about 22 cubic feet of gas; that works out to from 4½ to 5lbs. per horse power.

14663. You are leaving out of account, of course, the coke produced from the coal?—Yes, I leave that out altogether.

14664. (*Mr. Briggs.*) That is pretty valuable, is it not?—Yes, you are quite right, it is; I had not thought of that.

14665. (*Professor Dixon.*) Then further on in your statement where you give the consumption of coal per horse power for electrical engines, there I suppose you mean the total consumption of coal, 15·2lbs.?—Yes, in the station.

14666. That means driving a steam engine in the station?—Yes; per unit sold.

14667. So that not only is there no general economy in coal, but there is rather a lack of economy also to the consumer in what he pays?—Well, I cannot say that because the consumer has no engineer to keep, he uses very little room, he can put in power at places where he could not put it in before, and it is a very great advantage to him to have the supply of current handy at his door.

14668. Yes, I was not thinking of that; I only referred to mere price per horse power?—No, if he put in the boiler and engine he would pay as much for coal as he pays for current. In addition to that he would have to pay an engineer to look after the place

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Mr. Michael Longridge.

30 April 1903.

14669. (*Sir George Armytage.*) You mean exclusive of labour?—Yes, exclusive of labour, purely for coal.

14670. (*Professor Dixon.*) You have been referring simply to the consumption of coal?—Entirely.

14671. Your point is that actually more coal is being used on account of the introduction of these electrical engines?—I should say so. Power is being used where power was never used before, in many cases. Of course it is only a small quantity.

14672. Is this analysis which you have given us largely made up from the boilers in Lancashire and the immediate district, or is it all over the country?—All over the country, and Scotland, and Ireland.

14673. That did not quite appear, but that is important? Yes.

Table IV., p. 253.

14674. (*Dr. Le Neve Foster.*) In your Table you mention at (*d*) the plain cylindrical type of boiler; do you mean an egg-ended externally-fired boiler?—There are a few with flat ends, but the greater number are plain cylindrical egg-ended boilers.

14675. And externally fired?—Yes.

14676. Would it not be better if you put that in the Table in order to make it plain?—But you cannot fire a plain cylindrical boiler internally. A plain cylindrical boiler is a boiler which has no internal flow.

14677. Yes, but you choose to give it that name?—Well, it is the name it is known by amongst engineers.

14678. Is it not better to give a name to it so as to make it clear?—Certainly.

14679. Then your statistics, as I understand, do not deal at all with improvements in marine engines?—No.

14680. Would they not show a very much greater improvement?—Are you speaking of engines or boilers?

14681. Well, the boilers and engines, but especially engines?—In engines, yes; I do not think they would much in boilers. But I am not competent to speak except from mere opinion; my experience does not lie in that way.

14682. Taking the broad question, with regard to the quantity of coal consumed per indicated horse-power, would not the marine boiler and engine put together show greater improvement than the stationary engine?—Yes, I should think they would probably.

14683. I mean, owing to the introduction of triple expansion?—The introduction of good engines has been more universal afloat than on shore, I should think.

14684. Owing to the great necessity, as it were, for saving coal which you have to carry?—Yes.

14685. From an answer which you gave, I gathered that you considered that producer gas for works was made almost entirely from anthracite. Is it not a fact that if you have a plant requiring, we will say, 100 h.p., you can use ordinary coal for the purpose of getting your producer gas?—Well, of course, there are one or two apparatus, but I should not like to put them in yet myself from what I can learn of them.

14686. You would not?—No.

14687. Not even if you required 100 h.p. and you were going to put in plant with recovery of bye-products?—No, not yet—from what I can learn. I believe there are some difficulties with the tar. I have no doubt that in a very short time such apparatus will be perfected; I have very little doubt about it.

14688. What would be the limit for the use of ordinary coal. Supposing you had a plant of 200 h.p., would it be economical, do you think, to use ordinary coal?—It would be economical with any plant if you could get an apparatus that would do it.

14689. Then you do not think there is any plant in the market at the present time?—So far as I can hear there are doubts about it.

14690. That is, about making producer gas from ordinary coal?—Yes.

14691. Therefore you mean that at the present time if you want to make producer gas for ordinary works you are driven to use anthracite?—I think so, or coke.

14692. (*Mr. Briggs.*) Or Mond gas. Do you accept Mond gas or not?—Well, so far as I can hear there have been difficulties even with Mond gas. Of course it is difficult to get to know these things, but you do hear of them. Mind, I wish to say that I believe in a short time you will have producers capable of using ordinary common coal.

14693. (*Professor Dixon.*) The difficult thing is to get the tar out?—Yes.

14694. (*Dr. Le Neve Foster.*) And that is a very important point to be considered?—Yes, in the practical working of a gas-engine; because the manufacturer does not look at the coal consumption so much as constant running. He must have his engine going round—something that will work continuously. That is the important point to the manufacturer.

14695. (*Mr. Young.*) Do you suppose there has been any change in the sort of coal used under boilers in the two periods?—Yes, there has been more small coal used in manufacturing districts—a lower quality of coal is being used now.

14696. Is not that an additional advantage?—Well, there is not so very much difference in the quantity used; it is more in the price. A small slack has very nearly the same calorific values as larger coal; it is merely a question of having sufficient draught to burn it. The quantity of coal used is not very different; the quality is different; it is cheaper.

14697. A great deal of that would be wasted, it would not be useable at all in the earlier period?—Yes, I daresay it would be so.

14698. (*Sir Lindsay Wood.*) I do not quite understand the calculation you give in the last part of your statement. You state the consumption of coal as being equal to 11·3lbs. per horse-power per hour?—Yes.

14699. Is that not very high?—Yes, it is high.

14700. I thought electric stations had their plant up to date with regard to the consumption of coal per horse-power?—Yes, but in a station they have to provide for a certain maximum load; that maximum load comes on, I suppose, in London during the winter at about from 5 o'clock to 7 o'clock or 9 o'clock, when everybody is dressing for dinner, and everybody wants all their light on; the electric power station has to provide plant for that, and then so as to be ready for fogs they have to keep boilers going always under steam, and in that way the coal consumption at a lighting station creeps up enormously.

14701. You mean it is horse-power wasted?—Yes, coal wasted.

14702. I should have thought 11·3lbs., even on those grounds, was a very high figure?—Of course it all depends upon what the average price of coal is. There is no question about 0·815d. per unit sold; that comes in the official returns which are published every month. Then, if you take the average price of coal at 10s. per ton, which I do not think can be far wrong, there is no question about the 11·3lbs.; it is not a matter of opinion, it is only a matter of arithmetic.

14703. Supposing it costs 5s. per ton, what would be the figure?—It would be twice 11·3lbs. if the cost of coal were 5s.

14704. Why does the price affect the consumption of coal per horse-power?—Because I base the consumption on the price. The official return is that 0·815d. is spent on coal per unit; that is how it is.

14705. You work backwards?—Yes; that is the only way I can get at it.

14706. Are not water-tube boilers coming in very much?—Yes, very much.

14707. I see in your Table I. there are very few of them—183?—That is so

14708. They, I suppose, are much more economical, are they not?—No.

14709. You think not?—No; but they are well adapted for certain classes of work.

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TWENTY-FIFTH DAY.

Tuesday, 16*th June* 1903.

PRESENT:

THE CHAIRMAN.

Sir GEORGE ARMYTAGE.
Sir WILLIAM LEWIS.
Sir LINDSAY WOOD.
Mr. BELL.
Mr. BRACE.
Mr. BRIGGS.
Professor DIXON.

Mr. J. S. DIXON.
Dr. LE NEVE FOSTER.
Professor HULL.
Mr. MACLAY.
Mr. SOPWITH.
Mr. TEALL.
Mr. YOUNG.
THE SECRETARY.
THE ASSISTANT SECRETARY.

Mr. MAURICE DEACON, called; and Examined.

SUMMARY OF EVIDENCE.

(1) COLLIERIES.

14710. ECONOMIES EFFECTED IN CONSUMPTION OF COAL IN RECENT YEARS.

During the past thirty years, considerable economies have been effected in the fuel consumption of collieries, which prior to that period were considered to be of no importance, the opinion of colliery owners generally being that the class of coal consumed had little or no commercial value.

In those days, it was the common practice to use egg-end boilers, working at 50 lbs. or less pressure per square inch. Very little attention was paid to the quality of water used, or to the temperature of the feed-water. The boilers and steam-pipes were frequently uncovered, thus permitting a great deal of radiation and condensation. The average duty of such boilers was probably not more than 4 to 5 lbs. of water evaporated per lb. of fuel used.

The description of engine generally used was the ordinary non-condensing drop or slide-valve type, with the single exception of large pumping engines, which were invariably of the Cornish type.

Some twenty-five or thirty years ago, the egg-ended boiler became largely superseded by the Lancashire boiler, but the pressure per square inch was not generally more than 60 lbs. A few years later, the pressure was commonly increased to 80 lbs. per square inch.

Amongst other extravagancies in fuel consumption were the use of furnaces for ventilating purposes, and of coal fires for lighting the pit banks.

Modern Practice.—Within the last ten years, boilers of 100 lbs., and within the last five years, of 150 and 160 lbs. pressure have been adopted. The use of this higher pressure has enabled steam to be used expansively, and so to effect considerable economies. Boilers and steam pipes are now thoroughly well covered, so as to minimise radiation and condensation; and more attention has been paid to the purifying of bad boiler water.

Considerable attention is now paid to the heating of feed-water, which is sometimes effected by conducting the exhaust steam into a feed-water heater containing tubes, and sometimes into a simple tank fitted with baffle plates. Economisers are also frequently used, by which the feed-water temperature may be raised considerably higher than by the ordinary feed-water heater.

During the past twenty years, some attempt has been made to economise steam by the use of expansion or trip gear, and in a few instances, by condensing.

Neither method is generally adopted.

The use of electric power for transmission to long distances has been adopted to some extent in the place of compressed air, hydraulic, and rope transmission.

Mr. Maurice Deacon.

16 June 1903.

Ventilating furnaces have been almost entirely superseded by fans, resulting in considerable economy, where the depth of the shaft is not great; and bank fires have given way to electric light or gas.

Economies to be Anticipated.—The principal economies to be anticipated may be summed up under the following heads:—

(*a*) The use of high pressure boilers of the most economical type.
(*b*) The use of pure boiler water heated to high temperatures.
(*c*) The adoption of mechanical apparatus for consuming fine and inferior fuel.
(*d*) The use of compound or triple expansion condensing engines, or of the steam turbines.
(*e*) The general adoption of condensing.
(*f*) Superheating.
(*g*) An extended use of electric power for transmission over long distances and for distribution.
(*h*) The use of gas producers and gas engines for generating electric power.

With regard to the above heads:—

(*a*) *Boilers.*—The most economical type of boiler, where the water is fairly good, is the water tube boiler of the "Babcock and Wilcox" or other similar type; but where the water is indifferent, the Lancashire boiler, fitted with mechanical appliances for the regular feeding of the furnaces, and the proper admission of air at the bridge to complete combustion, is an economical boiler. The highest convenient pressure which is at present used at collieries is 150 to 160 lbs. per square inch, and this appears to be the limit under existing conditions.

(*b*) *Boiler Water.* By the use of pure boiler water and the consequent avoidance of incrustation, considerable economy may be effected. On certain tests carried out by me some time ago, an economy of about 20 per cent. was effected in a perfectly clean boiler, as compared with a boiler containing from $\frac{1}{2}$ in. to $\frac{3}{4}$ in. incrustation. The most economical and effectual manner of producing good boiler water is to use surface condensers, the condensed steam being used over and over again, with the addition of sufficient water to make up for the loss which occurs by leakage. By this process, not only is the water made pure, but the advantage of the vacuum is also obtained. It is necessary, however, to see that the oil used in the engines is separated as far as possible from the water, in order to avoid the risks of corrosion in the boiler. There are several chemical water purifiers in use, which will purify water at a cost of from $\frac{3}{4}$d. to $1\frac{1}{4}$d. per 1,000 gallons, according to its quality. The first cost of such apparatus is not

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Mr. Maurice Deacon.

16 June 1903.

very great, and the cost of softening is infinitesimal as compared with the advantages to be gained by the use of good water.

(*c*) *Mechanical Stokers and Furnaces.*—There are many forms of mechanical stokers and furnaces designed for obtaining a high evaporation and fuel consumption, the most perfect of which is probably the "Schwartzkopff" stoker, which uses powdered fuel in the form of gas. The duty of a tubular boiler fired by fine coal dust with this stoker has given as high results as 10 lbs. of water for 1 lb. of fuel. There are, however, mechanical and financial difficulties in adopting this method generally at collieries. The extended use of any form of stoker which will enable fine and inferior fuel to be used will result in economy. These may either be of the mechanical shovel type, with moving bars, or of the fixed hollow bar type, with the admission of heated air to the furnace. By the use of forced draught furnaces, coke-dust may be utilised with advantage.

(*d*) *Compound Engines.*—When the pressure of steam is upwards of 100 lbs., economy is effected by the use of compound engines. By the use of pressures exceeding 150 lbs., triple expansion engines may be used with further economy, but the capital outlay on the latter is not, in my opinion, warranted where an inferior class of fuel is used. The economy of compound engines is greatly increased by condensing. A greater use of trip gear, by which the steam may be used expansively, leads to a considerable economy with pressures of steam exceeding 100 lbs., in non-condensing engines, and with lower pressures in condensing engines. The use of the steam turbine for actuating electric plants or for other constant running purposes, may be economically adopted where condensing can be resorted to, the steam consumption being as low as 16 and possibly 14 lbs. per I.H.P.

(*e*) *Condensing.*—The question of condensing requires more consideration in the future than has been given to it in the past by the colliery owner. Much depends, however, upon the class of fuel consumed and the character of the boiler water. Where the boiler water is good and does not require purifying, and the fuel used is of very low value (say 1s. 6d. a ton), it is doubtful whether any commercial advantage is to be gained by condensing; but where it is desirable to purify the boiler water, condensing may be economically adopted where the fuel is worth only 1s. per ton. On the Continent, central condensers are largely adopted, into which the steam from all the engines at certain collieries is conducted. The steam consumed per I.H.P. in an ordinary non-condensing winding engine varies from 50 to 100lbs., whereas an ordinary condensing engine, with high pressure steam and expansion gear, will probably not consume more than 30 lbs. The steam consumed in the numerous smaller engines used for hauling, air-compressing, etc., is probably not less than 70 to 100 lbs. per I.H.P. at most collieries. Modern engines, using high pressure steam and fitted with trip gear, should not consume more than 20 lbs.

(*f*) *Superheating.*—Whilst the superheating of steam will undoubtedly lead to economy in fuel, it is not, in my opinion, economical from a financial point of view where the fuel is of a lower value than 2s. per ton, the interest on capital and depreciation absorbing any advantage which may be obtained in fuel economy. It is only, therefore, at collieries using coal of greater value that superheating may be economically adopted.

(*g*) *Electric Power.*—Great economy may be anticipated from the extended use of electricity for transmitting power long distances both on the surface and underground, and in superseding the numerous small engines which are used about the surface of a colliery for various purposes. Compressed air, which has been largely used for underground haulage, is gradually being superseded by electric power. The useful effect of the former seldom exceeds 20 per cent. of the steam power exerted in the cylinder, and assuming the engine to consume 50 lbs. of steam per I.H.P., the ultimate steam as applied at the motor will be no less than 250 lbs. per I.H.P. A well-designed electrical plant, with compound condensing engines, will consume from 14 to 16 lbs. of steam per I.H.P, and the loss by transmission, in cables of ample size, should not exceed at the outside 5 per cent. In the numerous small engines used on the surface, the steam used per I.H.P., including condensation in the pipes, is probably not less than 150 lbs. per I.H.P. With electrical power, the same work can be performed for under 20 lbs. Further economy in fuel may be effected by the provision of electric power to small consumers by power-distributing companies, whose large central stations will enable the most economical results in fuel to be obtained.

(*h*) *Gas-producers and Engines.*—By the use of an economical form of gas-producer, an I.H.P. may be created through the medium of the gas engine at an expenditure of a fraction over 1 lb. of small fuel. The best result obtained in steam engines, is, so far as I am aware, about 1¾ lbs. of fuel, but with fuel of a higher value. Probably the result with fuel of equivalent value is 2½ lbs., and this only in a triple expansion condensing engine. Gas engines are, however, only suitable for constant running purposes, and are not, therefore, suitable for colliery winding. The commercial value of a gas producing plant to a colliery owner, is, however, greatly reduced by the fact that it is not economical to put down a plant of less than 1,000 H.P., consequent upon the heavy capital charge and cost of working. Where the power exceeds 1,000 H.P., however, there is no doubt that the gas producer and gas-engine would under ordinary conditions be more economical than steam. Gas-producers may be adapted to the use of ordinary gas-coke instead of coal. Very satisfactory results are obtained in some instances in this way.

Generally, I am of the opinion that the economy of a modern colliery plant of the first order, as compared with an average plant of say twenty-five years ago, is probably 50 per cent. more economical in fuel consumption, that is to say, approximately 2½ per cent. of the output as against 5 per cent. Assuming that all collieries in the United Kingdom at some future time will be worked on these more economical lines, an economy of 4,500,000 tons would be effected on the basis of an output of 225,000,000 tons a year.

(II) IRON WORKS.

The economy of fuel at Iron and Steel Works has already received much attention.

Blast furnace surplus gases have been used for steam raising and for heating blast for many years.

Closed top furnaces are more in use than they were some years ago, but it is still the custom in Derbyshire and in some portions of other counties in the Midlands to allow a large amount of heat to be wasted through the furnace tops. Where this practice is adopted, it is generally necessary to use some fuel in raising steam. Considerable economy might be effected by the use of closed top furnaces in all cases, but there is a fear amongst some Blast-Furnace Owners of some risk of explosions occurring where coal is the principal fuel used. I have not myself, however, experienced any serious difficulty in this way.

The use of waste gases from Blast-Furnaces for heating boilers is not the most economical manner of utilising the gases, owing to the great loss in radiation which takes place. This loss of power is from five to six times more than when the gases are used direct in the gas-engine.

The loss of power arising from open-top furnaces is difficult to estimate with accuracy, but taking as an example the ordinary Derbyshire blast-furnace using coal, with an output of 250 tons per week of pig-iron, the theoretical quantity of gas produced would be about 65,000,000 cub. ft.; deducting from this one half for the heating of the stoves, and one-fourth for steam raising, there remains 24,375,000 cub. ft., representing about 1,450 H.P. if used in gas engines. Probably the actual available quantity would be considerably less.

Gas-engines for the utilisation of blast-furnace gases have not, until recent years, been successfully operated in England, but they have for some time been successfully used in Belgium and Germany, where they are used for blowing as well as for general power purposes.

A gas-engine plant for generating electric power has been for some time successfully in use at the Sheepbridge Iron Works. There are two engines, having cylinders 22 in. diameter, and 3 ft. stroke, each nominally 100 H.P., but working when required up to 140 H.P. These drive two continuous current dynamos, 92 H.P. each, which provide the power for driving the cranes, loam mills, blowers, fans, fitting-shops and other engines, in connection with a large cast-iron pipe foundry. The blast-furnace gases are passed through a small purifying plant, consisting of a washer, condenser and baffle, and coke and saw-dust

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scrubbers. The cost of the plant per I.H.P., exclusive of the generators, amounted to £14. The cost of a steam plant, including the necessary boilers and engines would be £28 per I.H.P. The gas engine plant being a pioneer plant was, however, obtained on very favourable terms.

In the case of a gas-engine, there is no fuel bill, no stokers' wages, and no boiler repairs.

Gas blowing-engines have recently been put down by a neighbouring iron works, and are, I believe, working successfully.

The economy to the blast-furnace owner ceases when he has reached the point of running the whole of his works without fuel. Beyond this point, he has no interest in affecting further economies, unless the surplus power can be devoted to outside purposes. The behaviour of the blast-furnace is, however, so uncertain, both in the quantity of iron produced and gas made, that it cannot generally be looked upon as a reliable source of power for public purposes. There may be cases, however, where a certain quantity of surplus gases might be relied upon, which could be devoted to purposes outside the use of the works themselves; but in order to avoid the risk of failure, a very large margin must be allowed for the possibility of some furnaces being blown out through the exigencies of trade, or, as periodically occurs, for the purposes of relining; and I do not think that any economy which may be made in this direction will be of great importance in the consideration of the preservation of the coal supplies of the kingdom.

Rolling Mills.—In both iron and steel rolling mills, considerable attention has been paid to the utilisation of waste heat. The waste heat from puddling furnaces and mill furnaces is utilised for raising steam. There is, however, room for some economy in the quality of coal used for this purpose. In some instances, small fuel has been used with more or less success by the use of the Siemens Regenerating Furnace. This furnace is also commonly applied to heating furnaces, in which an economy of about 50 per cent. of fuel may be realised. At many of the best equipped rolling mills, electricity has been largely introduced for actuating more or less the whole of the plant, excepting the mills themselves, for which purpose it is unsuitable, owing to the frequent variations and intermittency of the load.

Generally, there is room at many iron and steel works for a more economical type of boiler, worked at higher pressures, and also for a more economical type of engine; and also for general condensing, and the extension of electrical plant.

14710.*(*Chairman.*) You are a member of the Institution of Civil Engineers, are connected with collieries, and, as we all know, have large experience?—Yes.

14711. You say that considerable economies have been effected in the fuel consumption of collieries during recent years?—Yes. I think during the past thirty years considerable economies have been effected.

14712. Is the question recognised by colliery owners as being of some importance?—It has not been in the past so much as it is now. In the past it was the general opinion amongst colliery owners that the class of fuel consumed at collieries was of so little value that there was no necessity for paying great attention to close economy; but at the present time I think that view is considerably altered, and that colliery owners find it necessary now to economise in every possible way they can where the financial results will be satisfactory.

14713. Should you say that that is due to what I may call a better understanding of the economies which are possible, or is it partly due to the increased value of the coal?—I think it is mainly due to the increased appreciation of the possibilities of economising fuel, and also to a certain extent, no doubt, to the better uses to which inferior coal is now put—that is, the better appliances for cleaning, and the greater appreciation of washing coal. All these things have been gradually growing upon the colliery owner as he has found it difficult to make both ends meet, and he has availed himself bit by bit of each of these opportunities of improving the selling price of his coal, or decreasing his cost.

14714. I suppose the enormous capital invested in large collieries really lends itself to that view?—Yes, that is so.

14715. It makes possible, on a large scale, what probably would be less practicable, at all events, on a small scale?—That is so, in many cases.

14716. Has the extended use of coke tended in that direction? May we take it that a larger amount of coal suitable for the purpose is now applied for the purpose of making coke?—Yes—you mean the extended manufacture of coke—that has made great strides within the last 30 years, and possibly the use of the retort form of oven, and the method of compressing slack, has encouraged coking. In the case of seams which, in their natural condition, coked in a Beehive oven, would make an inferior coke, or perhaps not coke at all, such slacks may now be coked by means of compression and the retort oven.

14717. It is possible to use the smaller coal for that purpose?—The smaller the better.

14718. Therefore, it supplies them to some extent with a market which did not exist before?—Yes.

14719. In the olden times, I suppose, the system of boilers, and the attention paid to the quality of water and the coal used for such purposes, would not compare favourably with the present day practice?—Certainly not; egg-end boilers of the most wasteful character, with wasteful engines and low steam pressures were used, and very little attention was paid to the covering of the boilers and steam pipes.

14720. I suppose no one puts down any egg-end boilers now?—Not that I am aware of. The only conditions under which they might put them down would be to utilise the waste gas in coke-oven flues, but certainly not for steam raising by fuel.

14721. What is the type of boiler principally used?—The Lancashire boiler is the type principally used at collieries.

14722. That is tubular—and they have been greatly increased?—Yes; they have superseded the egg-end boilers, which have been taken out and thrown on the scrap-heap. Water-tube boilers are used where the water is good.

14723. Is any coal used now for the purpose of ventilation by means of furnaces?—Very seldom now; only in a few cases are ventilating furnaces used now.

14724. I suppose that system would not be adopted now at the colliery?—Certainly not.

14725. Would you say that the boiler pressures have been largely increased?—Yes.

14726. Tell us what you consider to be the most modern practice?—The most modern colliery practice, speaking generally, is a boiler pressure of 150 to 160 lbs. That seems to be the limit to which it is found desirable to go at present at collieries.

14727. I understand you to say that greater care is paid in order to economise radiation and condensation, and that attention is paid to the purifying of bad boiler water?—Yes; that is a great point, and one which has not had the attention I think it deserves, namely, the purification of bad boiler-water. I still find wherever I go bad boiler-waters being used, which cause a heavy incrustation in the boiler, rendering the evaporative power much below its proper duty, and at the same time causing injury to the boiler by the over-heating of the plates.

14728. Is the practice of heating the feed-water to the boilers now generally observed?—Yes, in a more or less crude manner. In some instances, it is observed in an excellent manner, that is to say, by the use of economisers, through which you can put your boiler water in at 280° or 300° Fahr., but the ordinary type of feed-water heater used at collieries is an old boiler either placed horizontally near the exhaust pipes of the engine to which it is coupled up, or placed vertically with baffle-plates at intervals down the sides of the boiler, the water coming in at the top and the steam coming in at the bottom. The baffle-plates break up the water into spray, and in that way you get 180° or 190° Fahr. temperature.

14729. Is that a method of utilising the exhaust steam?—Yes, utilising it for heating purposes; it gives no vacuum; you extract from the exhaust steam a certain amount of heat, which enables you to put your water into a boiler at a higher temperature.

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Mr. Maurice Deacon.

16 June 1903.

14730. Are the engines for colliery purposes mainly high-pressure engines, or are many of them condensing engines?—There are a good many condensing engines for certain purposes, for instance, pumping—large pumping engines are almost invariably condensing engines; winding engines are not. There are one or two exceptions, but it is quite a modern practice in this country to have condensing winding engines. On the Continent it is not so. It is quite a common thing there for winding engines to be connected to a central condenser in which the exhausts from all the engines at the colliery are taken.

14731. Does the question of water determine it, or the opinion of the particular administrators?—With regard to winding engines, I think in this country it has been a question whether the winding engine which is condensing can be as safely, rapidly, and conveniently handled as a high-pressure engine.

14732. Starting and stopping?—Yes, starting and stopping. I think that is one matter that has weighed with English colliery owners.

14733. Do you think yourself there is any difficulty?—I do not think there is. I have not had a very long experience in the use of them myself. I have one working now, and we do not find any difficulty as a matter of fact. I have not observed on the Continent that there has been any difficulty. At the same time, the winding engine is a most important machine at a colliery; its duty is to get out all the coal it can in the shortest possible space of time; and the question as to whether it is worth the colliery owner's while to place any sort of hindrance in the way of doing that is an open point upon which every colliery owner has his own opinion. I have myself some doubt as to the advantages.

14734. The rapidity of action and the certainty of action, you would say, are of the first importance?—Yes.

14735. And economy of the second importance?—Yes. You asked me whether water was an important factor; that is so, to some extent, but not to a large extent. Surface condensers are used, and cooling ponds, or cooling towers; and the water difficulty is got rid of to a large extent, because you use over and over again the same water cooled for condensing the steam a second and third time, and so on; and then all the water you have to find is what is commonly called make-up water to replace evaporation and loss by leakage.

14736. And the loss which is due to the supply of the boilers—that water is used again in the boilers?—That is so.

14737. Does that pass through feed heaters?—It is desirable that it should do so because of the temperature.

14738. What sort of temperature would it be when it comes out of the condenser?—The temperature, as a rule, should not exceed 112° to 115°; possibly it might go up to 120°, but that is not an ideal temperature for feed water for a boiler.

14739. Does electric power play any part in connection with colliery work?—Yes; electric power has been developed very rapidly in connection with collieries. I think the colliery owner has arrived at the conclusion that wherever power has to be transmitted a considerable distance, or where it has to be distributed over a considerable surface, electric power is the most economical method of doing the work.

14740. Would you tell us what, in your view, are the principal economies to be anticipated?—I summarise the economies in this way: (*a*) The use of high-pressure boilers of the most economical type. (*b*) The use of pure boiler water heated to high temperatures. (*c*) The adoption of mechanical apparatus for consuming fine and inferior coal. (*d*) The use of compound or triple expansion condensing engines, or of steam turbines. (*e*) The general adoption of condensing. (*f*) Superheating. (*g*) An extended use of electric power for transmission and for distribution. (*h*) The use of gas-producers and gas-engines for generating electric power. Now permit me to go back to the first one, namely, the use of high pressure boilers of the most economical type. The main advantage in using a high-pressure boiler is that you can use your steam expansively. With low pressure steam it is not economical to cut off your steam admission at an early point in the stroke unless you are condensing, and in that case it is. But in high-pressure engines it is not, I think, economical to expand your steam unless you have a pressure of 80 lbs. to the square inch.

14741. Or upwards?—Yes, or upwards; a minimum of 80°; then, the degree of cut off must only be moderate, and it must be apportioned to the pressure. With 80 lbs. pressure it would not be economical to cut off earlier than a ⅗ stroke; gradually, as the pressure increases you may cut off a little earlier; so that when you get 150 lbs. to 160 lbs. you may cut off at an early point in the stroke, and use your steam more economically.

14742. Have you any views as to which is the most economical type of boiler?—I think with good boiler water, the most economical type is the water-tube boiler of the Babcock and Wilcox, or, the "Sterling" type; they are all much of the same kind. You get a high evaporation out of them, and you get steam up very rapidly. But where the water is bad I have not thought it desirable to use them, because of the difficulty due to the incrustation of the tubes.

14743. What do you say about the purification of boiler water?—The purification of boiler water may be effected either by chemical means, or, better still, by the use of surface condensers and the utilisation of the distilled water resulting from the condensed steam. There are several methods of purifying water chemically, and the cost of purification is very small indeed in proportion to the advantage to be gained from using pure boiler water. I have been rather astonished it has not been resorted to to a very much greater extent by colliery owners than is the case. A bad boiler water, say a water containing 26° or 28° of hardness which would form a very bad boiler water indeed, and give a very hard incrustation may be purified at a cost of about ¾d. per 1,000 gallons. You may have to all intents and purposes a pure boiler water. The cost of that is so very slight that there can be, I think, no doubt at all as to the desirability of adopting some such method of purifying the water; unless you condense. If you condense, and use your condensed steam over and over again, then you have an absolutely pure boiler water, with the exception of the grease which may get into the steam, and then it is necessary to filter in order to avoid the risk of corrosion in the boiler. I have found no difficulty in intercepting the oil by means of filters to a sufficient extent to prevent any injurious effect in the boiler. The first cost of these purifying plants is small. There is no difficulty, it seems to me, at all in the way of adopting them. For instance, a plant of sufficient capacity for purifying water containing 28° of hardness for a colliery raising 2,000 tons a day at a depth of 540 yards cost me £800.

14744. The original outlay?—Yes, and the cost of purifying the water is ¾d. per 1,000 gallons.

14745. ¾d. per 1,000 gallons of fresh water used?—Well, it comes to the same thing; it does not diminish the quantity of water. For every 1,000 gallons passed through the purifier the cost is ¾d.

14746. (*Professor Hull.*) Is that a different system of purification from Porter Clarke's system?—Yes; the process I am referring to is a different process; it is the "Howatson" process.

14747. (*Chairman.*) Speaking of water with 28° of hardness, is there one process which is best fitted for dealing with waters of that kind, or does the process depend upon the hardness?—I think it depends, to some extent, upon the chemical constituents of the water; for instance, the Howatson process, which I have just referred to, would not be a suitable process for sulphates, I think.

14748. Tell us in your opinion what the cause of the hardness is?—It is the carbonate or sulphate of lime.

14749. You find the process you have mentioned has been effective in your own case?—Yes. In the case of waters containing sulphate of lime to a large extent I am inclined to think the Archbutt Deeley is the better process.

14750. What is the name of the process you use, and of which you have spoken?—The Howatson.

14751. But surface condensers of which you have spoken would not deal with water of that description without its being purified in the first instance?—Yes, they will do so. In some cases it may be desirable to soften the water first, but with a surface condenser you may get a deposit of an incrustation on your tubes which may

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be removed by the use of muriatic acid. I am using a surface condenser now with hard water, and from time to time we remove the scales by means of this chemical mixture, and the tubes are kept clean in that way.

14752. What do you say about mechanical stokers and furnaces?—There are many kinds of mechanical stokers. Experiments have been made for many years and they have not altogether been successful and not very generally adopted, but there is no doubt, by their use, a finer fuel may be used than can be used in the hand-fired boilers.

14753. Do you distinguish between what you call "fine coal dust" and "inferior fuel"?—Well, no; I say "fine," because I do not think a mechanical stoker will enable you to burn an inferior fuel any better than if it were hand-fired; the fineness, I think, is the main point; except, perhaps, that the mechanical stoker distributing the inferior coal more evenly over the furnace, would enable you to get a little better evaporative power out of it. But the main point is this: in hand-firing boilers you must have a fuel to a certain extent rough or nutty, whereas, with a mechanical stoker you may use absolutely fine dust. There are many kinds of stoker; there is the ordinary shovel stoker which throws the fuel on to the fire in small lots; then there is the stoker which partially cokes the coal on the shovel before it is thrown on to the fire. Then there are movable bars, and the chain grate (Babcock and Wilcox), which is a very good kind of grate; a chain grate takes the fuel forward constantly and tips the ashes over at the end of the furnace after the combustion is finished. One of the main points in completing combustion is to admit sufficient fresh air at the back of the furnace. There are many methods of arriving at that. There are hollow fire bars, for instance, by which the air enters at the front of the bar and passes up through the centre of the bar and then is admitted at the back of the furnace by the bridge; and the admission of that air at a high temperature assists in the final combustion of the fuel.

14754. Is the temperature got entirely by the means you describe of passing through the bars?—Yes, passing through the bars in that case. There is another method by which tubes providing the furnace with air are placed in the main flue at the back of the boilers and conducted through the boiler flues to the furnace at a high temperature.

14755. Practically, that would be waste heat, I suppose?—Yes, partly waste heat, not entirely; waste heat so far as the main flue is concerned, but not waste so far as the longitudinal flues in the boiler are concerned. Air being delivered into the furnace at a very high temperature and at a point where it is particularly required for the completion of combustion gives a very good duty; a high evaporative power of the boiler diminishes the smoke to a very large extent, in fact with ordinarily careful firing it almost entirely consumes the smoke.

14756. You speak of high temperature. Can you tell me what it is?—I cannot tell you what the temperature is exactly; it is a very difficult thing to take because it is all inside the flue of the boiler; but I should think the temperature of that air would not be less than 1500° probably, or it may be a little more.

14757. Is quantity required as well as a high temperature?—In this apparatus I am referring to now, which is called the Incandescent Furnace, the whole of the air which supplies the furnace is brought through these tubes, heated first of all in the back flue, and then finally conducted to the front of the boiler. The front of the boiler is absolutely closed. Before leaving this subject I should like to call your attention to the Schwartzkopff Stoker, which is a German invention.

14758. Can you describe it to us?—Yes, I will describe it. It consists of an apparatus by which extremely fine fuel, fuel which is specially prepared and ground like flour into an impalpable powder, is thrown into the furnace by means of a revolving brush—it practically forms a gas in the furnace and burns in appearance like a blast furnace gas.

14759. How is it ignited in the first instance?—They ignite it with a piece of waste on a stick dipped in paraffin and thrust into the furnace.

14760. There is no body of fire?—Simply flame; and if the dampers are properly regulated the whole of the fuel is consumed and there is no smoke whatever.

14761. Any ashes?—A little dust—not ash.

14762. Does that remain outside?—It goes into the flues, but it is caught at the end of the main flue and cleared out periodically. There are methods of dealing with the dust in order to prevent any loss of efficiency in the boiler. The apparatus is extremely economical in weight of fuel used and the results are very satisfactory in the matter of evaporation of water in relation to the fuel used. In the case in which I saw it in use, an evaporation of 10 lbs. of water per lb. of very fine dust was being obtained from a water tube boiler. I think it was a Babcock and Wilcox.

14763. Was that German coal?—No, English coal. This stoker is in use at Richard Evans' collieries in Lancashire. It was put down by the Schwartzkopff people as a sample plant, and it is using very fine dust, screened at the colliery through a $\frac{1}{8}$-inch mesh. Then this fine stuff is ground up again into powder and used as I have explained.

14764. Is the dirt washed out beforehand?—No, that is not washed coal.

14765. Nor necessarily of a very high quality?—Not necessarily. The higher the quality the better the evaporative power naturally. The difficulty in adopting this plant is, first of all, the high capital cost; and, secondly, the failure at present to find a means of grinding the coal which is satisfactory. The wear and tear is so great that it has formed a hindrance to its general adoption.

14766. The cost of grinding is probably more than the cost of the coal per ton?—There is not sufficient advantage in the economy of the use of the fuel in the boiler to pay for all this expensive machinery and the heavy wear and tear. The apparatus itself is certainly the most perfect I have seen, except that from the financial point of view it can be only used under certain conditions.

14767. I gather from what you say that the large capital outlay necessary for the plant is an outlay due to the costly nature of the plant and not to any prohibitive patent fees or anything of that kind?—Yes, to the costly nature of the plant. I do not think the patent fees are exorbitant. They are rather high; I forget what they are at present, but they are not absolutely prohibitive, I think.

14768. Do you know whether this stoker is in use anywhere else except at Messrs. Evans'?—It is in use at one colliery near Leeds—the Middleton Main. They fitted one boiler with it; they had great difficulty with their grinding arrangements, but they are still using it, I believe.

14769. Does the coal require to be dried before being ground?—I think it is very desirable it should be dried. I do not think it is artificially dried; I think it is simply kept from moisture and the process of grinding dries it to a sufficient extent.

14770. They wash most of their coal at Middleton, do they not?—Yes, they wash their coking coal; but this coal is used before it is washed.

14771. Now what do you say about compound engines?—Well, economy may be effected to a greater extent than now by the use of compound engines with the use of higher pressure steam; but with the present low pressures which are used at many collieries (that is to say, 60 to 80 lbs.), there is no economy in compounding unless it is accompanied by condensing. With higher pressures, up to 100 lbs., there is economy in compounding without condensing.

14772. What about triple expansion?—Triple expansion effects a still further economy; but the great cost of triple expansion engines is almost prohibitive at a colliery. Where the cost of fuel used is low, as it is invariably, being the small and inferior quality, and there being no railway rates and wagon hire to pay upon it, the saving does not warrant the expenditure of large capital in triple-expansion engines. But that does not apply to compound engines, because you can adopt a twin compound engine which is very little more costly than a high-pressure engine with two cylinders.

14773. Are there any triple-expansion engines working

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Mr. Maurice Deacon.

16 June 1903.

at collieries, so far as you know ?—There are triple-expansion engines for pumping, but not for general purposes, I think.

14774. (*Sir William Lewis.*) Not for winding ?—No.

14775. (*Chairman.*) I suppose the portion of power used for winding and pumping respectively varies considerably at different collieries ?—Very much indeed. Some collieries raise five or six times as much water as coal.

14776. In tons ?—Yes ; others are more fortunate, and raise very little water.

14777. Would you say, speaking generally, that the power expended in pumping is as great or greater than the power expended on raising coal ?—I am afraid I could not answer that question—not as applied to the whole country.

14778. I think you speak about steam turbines ?—Yes, the steam turbine is a useful machine for driving dynamos or other constant running machines. When condensing the steam the consumption is very low. At the present moment I am having steam turbines made which are guaranteed for a fuel consumption of 14 lbs. of steam per i.h.p., which is a very low consumption. I am using turbines now which are giving 17 lbs. consumption, and that in colliery practice is very low indeed.

14779. That is with condensing ?—Yes. Without condensing they are not economical in steam—not so economical, I think, as an ordinary well-designed engine used expansively.

14780. They are more applicable to constant running ?—Yes, absolutely ; they are constant running—they cannot be used for any other purpose.

14781. Is the use of them extending ?—Yes.

14782. For electrical purposes ?—Yes.

14783. And for electrical purposes for power as well as light ?—Yes.

14784. But, as far as you know, in colliery practice for electric lighting purposes only ?—Well, I have known them used for ventilating purposes, for fans, but I have never put them down myself for this purpose, and I do not think I should feel disposed to do so, although I do not know of any mechanical reason why they should not be economical for driving fans.

14785. The duty is continuous?—Yes.

14786. (*Mr. Briggs.*) Have you ever known them used for underground haulage?—Do you mean "direct"?

14787. For instance, driving an endless rope?—No, I have never used them for that.

14788. They might be used for that?—Yes. The speed is so very great you would have to reduce it down by gearing ; that is the main difficulty, and the same difficulty applies to the fan, unless you use a very small fan and run it at a very high speed. I know of one instance where the fan runs at 1,400 revolutions a minute ; unless you have a machine which you can drive at a high speed I do not think they are more economical, if so economical, asan ordinary steam or gas engine, because you have all the gearing and the loss of power in the gearing in reducing your speed from the turbine down to the speed of the motor.

14789. (*Chairman.*) At what speed does a turbine run?—They vary. I am putting down one which is to run at 3,000 revolutions a minute.

14790. What do you say about condensing ?—I have already said a good deal about that ; I think all I need add is that for all colliery engines with the exception, or partial exception of winding engines—I do not class them absolutely with other engines—condensing is desirable. I think that where the value of the coal, which is used for raising steam is upwards of 18d. per ton, condensing will be found to be economical. If fuel is only 18d. a ton or less, I think that the interest and depreciation upon the cost of the plant will amount to as much as the saving which is gained by the vacuum. But when the question of boiler water is brought into consideration there is a distinct advantage, if the boiler water is bad and it is desired to purify it, in condensing, even when the cost of fuel is only 18d. or 1s. per ton. I will go as low as that. Where you combine the two points, purifying boiler water and condensing, then you obtain advantage by adopting condensing if the fuel is of the most inferior character and only worth 1s. a ton.

14791. Then would you put the difference between good and bad water as high as 20 per cent. to 30 per cent.? —I made some tests some years ago, by which I found that the duty of a clean boiler was 20 per cent. better than the duty of a boiler incrusted from $\frac{1}{8}$ to $\frac{3}{4}$ of an inch. I am sorry I could not find the particulars of those experiments, so as to have brought them with me ; but I had a number of experiments with incrustations of different thicknesses, and the loss varied from 5 per cent. up to 20 per cent ; 20 per cent. was the greatest loss I found.

14792. You say that on the Continent central condensers are largely adopted into which the steam from all the engines at certain collieries is conducted. Is that practice observed in this country?—It is in one or two of the most modern collieries ; but certainly not generally. In fact, only in a very few instances.

14793. The advantage of that is to get the water altogether?—The advantage of that is first of all to condense the whole of your steam ; and, secondly, to centralise your plant in one item instead of having a number of items distributed.

14794. Does it give you a better choice of site?—Yes, it takes up less room—that is the point you mean, I take it.

14795. I meant rather at a particular point where you have your engine, for example, the space may be very valuable by reason of the construction of the plant?—Quite so.

14796. Does the provision or the use of a central condenser for a works, generally say, afford you an opportunity of putting your central condenser anywhere? —Yes, certainly.

14797. What do you say about superheating?—Superheating is economical where the cost of the fuel is high ; but I do not know of any case where it could be adopted with great advantage at a colliery where the cost of fuel is invariably low.

14798. You say that the use of the waste gases for the purpose of heating the feed water was perhaps as good an application as you could make of them?—Yes, I think that is as good a use as you could make of them ; first of all reducing the temperature of the waste gases to the lowest possible point. One method of doing that is the method of seating the Lancashire boiler so that the gases are finally brought over the top of the boiler instead of along the side flues. The usual way is for the gas to go up the two flues, back underneath, and then finally along the sides. In the plan which I have adopted, instead of having side flues, I intercept the heat in the bottom flue of the boiler by means of fire clay guides, which absorb the heat and return it to the boiler ; and that reduces the temperature of the gas to a sufficiently low degree to permit of its being taken back over the top of the boiler without any fear of injuring the outside of the boiler plates. That dries the steam. It is not superheating, although sometimes talked of as superheating. It has the effect of drying it, and in that way you may utilise your heat to very good advantage. At the present time I have boilers seated in that way, and the waste gases are only 200° Fahr. at the chimney, which is from 300° to 400° less than in the ordinary method of firing.

14799. Do you think there is an advantage in making your flues big enough?—I think that is a very important matter. Very often the efficiency of a boiler is crippled by the flues being too small.

14800. You have already said something about electric power?—I think the greatest economy which may be effected in the future in collieries is by the extension of the use of electric power. The old-fashioned, or, I should say, the average colliery non-condensing high-pressure engine, working at say 50 to 60 lbs. pressure, which is a common practice even to-day, uses a very large amount of steam ; and when the engines are distributed, scattered about the surface, as they invariably are for different purposes, there is a great loss in radiation and condensation in the steam pipes. So that if you take the i.h.p. of all the engines on the surface at an average colliery, and then take the quantity of water

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evaporated in your boilers, it is not an uncommon thing to find that the steam used per i.h.p. runs up to a very high figure—up to 100 lbs. per i.h.p., which is perhaps rather an alarming statement to make. An ordinary winding engine uses about 50 lbs. of steam if running pretty constantly, and the steam is not unduly cooled down, and condensed by the cooling of the walls of the cylinder while the engine is standing. So that it does not seem so very alarming to talk of 100 lbs., when you bear in mind that the winding engine is close to the boilers invariably, where there is very little radiation, and that a number of the other engines are scattered all over the surface with long lengths of steam-pipes, and many of them use steam less economically than the winding engines.

14801. (*Mr. Brace.*) Would you advise the use of electric power in a fiery mine for all its purposes?—I think there is no reason why electric power should not be used in a fiery mine near the pit bottom, in the intakes.

14802. The haulage rope must go further than the pit bottom?—Yes, but the power is applied near the pit bottom. You simply have your return wheel inbye if it is an endless rope or main and tail rope, and if it is a single rope you simply have the rope attached to the end of the set of trams. There is no occasion to have electric power inbye unless you want to use it for auxiliary purposes or pumping. Those are the two instances in which it may be necessary to take it in if you use electric power entirely.

14803. (*Sir William Lewis.*) Or coal cutting?—Yes.

14804. You would confine it entirely to the pit bottom?—A great deal depends upon the circumstances. I should not like to say that I would confine it entirely to the pit bottom. I think it is impossible to make a general statement on that point. I think every colliery manager should use his own discretion as to whether it is safe or not.

14805. (*Chairman.*) You spoke of the importance of covering the boilers and steam pipes. Has there been any progress made with respect to finding material which is effective for that purpose?—Yes, I think there has. The old-fashioned method was a mixture of mortar and cow-hair and so on, plastered on, and it was, in its way, very good; but the experience in most collieries was that it frequently got knocked off and was in a state of constant disrepair during which time radiation was going on. The method I have adopted lately is the use of silicate cotton covered by steel plates, and not only are the pipes and boilers covered in that way, but the flanges of the pipes are covered by means of hinged boxes which can be turned back to make the joint. The radiation of heat is extremely small. I tried it as an experiment to satisfy myself that I should be warranted in paying nearly double the cost of an ordinary covering. I had two lengths of pipes which ran parallel with each other covered, one with silicate cotton and the other with ordinary composition, and the difference in the radiation of heat was so very marked that I was quite satisfied that the silicate cotton was cheap at double the cost, and I have used it in every case since. The radiation is so high that you may put your hand on the covering on a steam pipe carrying steam of 100 lbs. pressure, and there is only a tepid warmth observed.

14806. Is that covering painted?—It is a burnished steel.

14807. Does it not rust?—Yes, I think it does in time, but when it begins to rust it is painted.

14808. That is the best thing you have found as a non-conductor?—Yes.

14809. (*Mr. Bell.*) What is the thickness of the silicate cotton?—About 1½ or 1¾ in., or it may be 2 in.

14810. (*Chairman.*) What do you say about gas producers and engines?—Gas producers for working constant running plant such as dynamos may be utilised with great economy. The best result of gas producers is about 1 lb. of fuel per i.h.p., which is something like half the best steam-engine.

14811. Including turbines?—Yes. If you have 16 lbs. of steam per i.h.p., or 8 lbs. of water evaporated per lb. of fuel, that would be 2 lbs. of fuel per i.h.p., whereas in a gas producer you can produce a h.p. for 1 lb. of fuel, and that comparatively inferior fuel. The Mond producer enables common small coal to be used—coal which would be worth 3s. to 4s. per ton at the pit's mouth—so that the economy is not only in the quantity of fuel per i.h.p., but in the cost.

14812. The advantage is mainly in cases where the power used is considerable?—That is so. I went very closely into the matter some time ago, with the intention, if I found my inquiry satisfactory, of establishing the process for the general working of a colliery, with the exception of the winding engine; but I found that the cost of the plant, and the cost of working it, was so considerable that for less than 1,000 h.p. it would not be economical to adopt it at a colliery. But where the cost of fuel is increased by a considerable railway rate and wagon hire, I think the conditions would be altered, and a smaller plant than 1,000 h.p. might be economical.

14813. Does that produce gas available for lighting purposes outside?—No, not in its crude form.

14814. Not with mantles?—No, not that gas, I think.

14815. You say that gas producers may be adapted to the use of ordinary gas-coke instead of coal, and that satisfactory results would be obtained in some instances in that way?—Yes. I have seen a plant working in Yorkshire where the whole of the power of a mill was obtained from gas-engines driven by a gas-coke producer; that is a producer using gas-coke only, and at a cost of 1½ lbs. of coke per i.h.p. The coke was costing 9s. a ton then, and the total cost of the plant was very low, I believe—I think only about £1,200 to £1,400 for 120-h.p. But it was astonishingly low, and I think, perhaps, that the reason was that it was an experimental plant, and the builders of the gas-engine put it in at a very low price. I do not think a similar plant would be built for the same price again.

14816. (*Sir George Armytage.*) What was the general power?—The whole power was 120 h.p., but the economical results were very striking to me indeed.

14817. (*Chairman.*) It is a convenient form as regards cleanliness, and so on?—Yes, very.

14818. And more adaptable to small powers?—Yes. You may put in a single producer on a very small scale, and the man who attends to the engine may attend to the producer, and so effect economy in labour.

14819. (*Sir George Armytage.*) Do you know what the cost of that plant was?—I believe £1,200 to £1,400 altogether—very little more than £10 per i.h.p.

14820. (*Mr. Briggs.*) That includes the gas-engine?—Yes.

14821. That is wonderfully cheap?—Yes, as I say, it could not be done again for the money.

14822. (*Chairman.*) Speaking generally, I gather you are of opinion that the economy in modern colliery plant of the first order is much greater than it was say 25 years ago?—Very much greater.

14823. Would you say as much as 25 per cent. more?—Yes; I think I have no hesitation in saying that is so.

14824. And if all the collieries in the United Kingdom could be made to see that it was to their advantage we should have a large saving in the coal consumption?—If you assume such a perfect condition of things as that the whole of the collieries in the Kingdom were provided with the most modern and economical plant you would have a saving of 4½ million tons per annum. You then assume something which is impossible at the present moment, but something which may not be impossible in the future.

14825. (*Mr. Young.*) What might be the capital cost of getting that saving?—That is to remove the existing extravagant plant and to replace it with modern plant?

14826. Yes.—I am afraid I could not answer that question. You mean for the whole Kingdom?

14827. Yes.—I am afraid I could not answer that question.

14828. (*Mr. Sopwith.*) Are you putting the consumption at 2½ per cent. in that case?—Yes, I think it would be possibly 2½ per cent.

14829. As against 5 per cent. as an average?—Yes, taking an average colliery.

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Mr. Maurice Deacon.

16 June 1903.

14830. Do you not think that the colliery average is slightly over 5 per cent?—Yes; I take an average of a modern colliery, not the average of the whole Kingdom. I say the average of a fair modern colliery to-day, without any exceptional difficulties with water, would be about 5 per cent.; and I say that that colliery, if it was fitted with the best appliances, would do the work at 2½ per cent.

14831. (*Chairman.*) That is a very important figure as regards the coal resources?—Quite so.

14832. (*Sir William Lewis.*) In assuming a saving of 50 per cent. you assume that the consumption of fuel in connection with the getting of coal 25 years ago was only 5 per cent., but now with modern appliances it would be 2½ per cent.?—No, I am assuming that now at an average modern colliery without any special difficulties the consumption would be 5 per cent.

14833. Now?—Yes, now, and at an average modern colliery; but with a new colliery fitted up with the best appliances, and running all its engines, except its winding engine, by electric power, and with condensing and high-pressure steam, and so on, then the consumption at that colliery would be only 2½ per cent.

14834. (*Mr. Sopwith.*) In your statement it reads as if the consumption was 5 per cent. 25 years ago, and is only 2½ per cent. now?—That is not my intention. I intend the 5 per cent. to apply to a present day average colliery. I think that is very well within the mark. I think the saving would be more than 2½ per cent. upon the ordinary colliery of 25 years ago.

14835. (*Chairman.*) As we understand, you believe that taking collieries, I will not say the antiquated ones, but taking the fair modern collieries of to-day, the consumption of coal for all purposes is about 5 per cent. of the total output?—Yes.

14836. And you believe that, with the most economical appliances which could be applied, that could be reduced to 2½ per cent?—Yes.

14837. (*Sir William Lewis.*) Consequently the saving that could be effected would be very much more than 2½ per cent.?—Quite so.

14838. (*Sir George Armytage.*) You mean 25 years ago it was probably 10 per cent.?—25 years ago it would be much greater.

14839. About 5 per cent. now, and it may be reduced half again?—Yes, I should think something of that sort. Take an ordinary colliery 25 years ago; if the saving would be 50 per cent. now as compared with the modern colliery of to-day, the saving with an ordinary colliery of 25 years ago would be probably double that.

14840. (*Chairman.*) Nearer 100 per cent., I suppose?—Yes.

14841. (*Mr. Briggs.*) Is it not a fact that collieries nowadays—I am speaking now of the older ones—have to use a great deal more fuel than they would have done 25 years ago, because of much longer distances on an average for haulage?—Yes, that is so.

14842. It is also, I think, a fact that a good many of these collieries, producing possibly one-third of the coal of the United Kingdom, are so old, and have such short lives before them, that it would be impossible for the owners to think of putting in anything like modern plant?—Quite so.

14843. Because they have not the life to pay for it?—Quite so.

14844. Under no circumstances can a marked economy be effected in those pits?—It could only be done on a gradual extinction of the old collieries and a gradual coming in of new ones to take their places.

14845. I find in my own experience we are paying more now, notwithstanding the fact that we have very much better appliances?—Owing to the distance you have to haul your coal?

14846. Yes, and numerous pits have the old-established plant—a number of small pits?—Quite so.

14847. That must always counterbalance the improvements which you say are possible?—What I am suggesting is not what I say is going to take place at once. I say that if you assume the condition of things which I laid down you would get it.

14848. Unless there are new collieries at which you have a greater depth to wind?—Yes.

14849. We are winding now on an average to a much greater depth than we did 30 years ago?—Quite so.

14850. We are looking at these figures to see what saving there can be with regard to our coal resources. I agree with what you say with regard to the possible saving, but I should doubt whether there would be any saving in actual tons of coal at all in the future. There will be greater physical difficulty, and there is the fact that the old collieries are getting more and more expensive?—I think that is very likely to be the case, but that does not affect what I have laid down.

14851. I do not doubt that; only from the point of view of this enquiry particularly, although this is possible, I doubt whether it will do more than stay the natural increase in the quantity of coal which would otherwise have been used?—That is very likely to be the case.

14852. (*Chairman.*) Of course it accentuates the importance of the economy?—Of course.

14853. Now with regard to ironworks; has the economy of fuel in iron and steel works received any attention?—Yes, it has received more or less close attention for many years, due principally to the fact that the quality of coal used is more expensive than the quality of coal for steam raising at collieries; and in many cases the coal has to be conveyed a distance and to bear the burthen of railway rates and wagon hire in addition to the high cost of the coal. This has necessitated very great care being taken in keeping down the consumption.

14854. Is more use now made of blast furnace gases for the purpose of steam raising and heat than in past years?—Blast furnace gases have been used for a very long time for raising steam, and I do not think there is any improvement in that respect; but I think that during the past 30 or 40 years there has been a great advance in the better saving of the gases by using closed top furnaces instead of open top furnaces.

14855. But still for steam raising?—Yes, until recently, when gas engines have been adopted for utilising blast furnace gases direct.

14856. That is an improvement?—Yes, but the heating of the stoves takes a large proportion of the total gases of the furnace; in the ordinary way it takes about half, we find, by practical experience. Half the theoretical gas made in the furnace is taken up in heating the stoves.

14857. Are open top furnaces disappearing?—Yes, they have disappeared over the whole kingdom with the exception, I think, of Derbyshire and South Yorkshire, and one or two works in Northamptonshire.

14858. Is there any reason why people should still continue to use the open top furnaces there?—I do not think there is any reason beyond the fact that the furnaces are there in existence, and there is some difficulty in applying a bell top to an existing furnace. The design of the furnaces is not of the best for the adoption of a close top.

14859. Profits have not fallen to the point that economies are necessary?—The point is mainly, I think, that generally speaking open top furnaces will provide all the power required for blowing those particular furnaces; so that unless there is some other outside power which the blast furnace owner wishes to provide he has no particular interest in economising his fuel any further. If he gets all the power he wants to drive the machinery, which will keep his furnaces going, he will obtain no advantage by closing the tops of his furnaces in order to obtain more gas, because he would have nothing to do with it.

14860. That is to say, if he gets the necessary power he wants, and the necessary heat that he wants, he has nothing further to gain?—That is so.

14861. Is there any question as regards the quality of the iron made in the one form and the other?—I do not think so; it is sometimes so argued.

14862. One is as valuable as the other?—I think so.

14863. And the quantity?—Yes, and the quantity is quite as good—there is no difference. It is held by some blast furnace owners, who make castings very

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largely, that an open top furnace will make more suitable iron for castings than a close top. I do not think so. I have both, and I analyse the iron from both once or twice a week.

14864. Therefore, as regards the quality and quantity of product, the close top gives you as much as the open top?—Yes.

14865. And the additional advantage of power for other purposes?—Yes.

14866. Is the use of gas engines using blast furnace gases extending in this country in large ironworks?—Yes, I think it is.

14867. Has it made any such progress here as it has made in Germany?—Nothing like it at present; but it is certainly making rapid progress now. I think the plant I put down was the first successful one. For some reason the other engines put down were pulled out or abandoned. The Claycross Company have put down gas-blowing engines, and Cochranes, of Middlesbrough, have recently done so also, and I think others are going down in various parts of the Kingdom.

14868. Could steam boilers be dispensed with entirely in the case of blast furnaces, such as you have described, if you got your power from the gases?—Yes, I think so. I do not think there is any use for them excepting for power purposes.

14869. You have made some estimate of the loss of power arising from open top furnaces, have you not?—No; I have made an estimate of the surplus gases which would be obtained from a close top furnace.

14870. You say the loss of power arising from open top furnaces is difficult to estimate with accuracy, but taking as an example the ordinary Derbyshire blast furnace using coal with an output of 250 tons per week of pig iron, the theoretical quantity of gas produced would be about 65,000,000 cubic feet?—What I wish to say is that, whilst an open top furnace would only supply just the amount of steam necessary to blow that furnace, and to perform the other work in connection with the furnace——

14871. That is, if used under a steam boiler?—If used under a steam boiler—the theoretical quantity of gas made and retained by means of a closed top would give a surplus after allowing for the heating of the stoves the driving of the blowing engines and for the hoisting engines and leakage. The estimate I made was that in the case of an ordinary Derbyshire furnace producing 250 tons of pig iron a week, the quantity of gas—assuming the consumption to be two tons of coal per ton of pig iron made—would be 65,000,000 cubic feet: and deducting half that for heating the stoves and for leakages, and one-fourth for steam raising, there would remain 24,375,000 cubic feet, representing about 1,450 h.p. But that is a theoretical statement which indicates the extreme limit of the possibility of the furnace. It must be borne in mind that a furnace is a very erratic structure; it has periods of fast driving, when it will make gas very rapidly, it has periods of restriction when it makes very little gas at all, and there are periods when it must be blown out altogether for relining purposes, and for various other reasons from time to time; and during all the different stoppages, of course, the furnace is not making gas. Therefore all these things must be taken into consideration and set against the theoretical quantity of gas which there would be to spare. The general conclusion I have arrived at is, that in a small plant—a plant, say, of three or four furnaces—there would be very little, if any, gas to spare for surplus purposes with any absolute degree of certainty. That is to say that whilst a blast furnace owner might put down a gas engine plant for other purposes, and utilise the gas when he could get it himself (being prepared to go without it when he could not get it), some considerable advantage might be obtained from the surplus gas from the furnace. But for public supply purposes, unless the plant were a very large one—eight or ten or 12 furnaces—there would be no reliable supply of gas which could be utilised.

14872. Is one of the difficulties the fact that it is in a form in which you cannot store it?—I do not quite understand that question.

14873. Ordinary gas you can put into holders, and you can store it, and therefore you can make gas which will last you for a good period of time; but it is difficult to store blast-furnace gas is it not, or to store the power which may be obtained from it? If you could use it continuously you have a supply as long as the furnace is going?—I do not know what the mechanical difficulty in storing blast-furnace gases might be. I should think it would be possible, by the erection of large gas-holders to store it.

Mr. Maurice Deacon.

16 June 1903.

14874. Would it?—I do not see why it should not be.

14875. You cannot store electricity if you turn it into that form?—No, you cannot store electricity excepting by means of accumulators. That is very costly, and only temporary, of course. But as a matter of fact we do use a gas-holder for our furnace gases—it is not for the purpose of storing large quantities of gas to take us over the periods when our furnaces are not yielding gas, but simply as a receiver, to give the engines some constant pull, that is to say, not to rely upon the supply of gas coming straight from the pipes.

14876. (*Sir William Lewis*). Many works have large regulators for that purpose?—Yes.

14877. (*Chairman.*) But one of the difficulties you mentioned to us—the furnace being out of repair—would be overcome if you could store the gas wanted to tide over the time when the furnace was out of repair?—Yes, that might be so; but even then in the case of a small plant—a plant with three furnaces—I do not think it would be applicable. I think the practical view of the matter is that where there are a large number of furnaces, say 10 or 12, the fact of one or more furnaces being out for repair would be averaged over the whole of the remainder, and that a certain quantity of the surplus gases might then be relied upon.

14878. You have, as you have told us, a gas-engine plant at the Sheepbridge Iron Works?—Yes.

14879. And it is used for what purpose?—For generating electric power.

14880. What h.p. are the engines?—They are nominally each 100 h.p.; they work up to 140 h.p.

14881. And they are driving continuous-current dynamos?—Yes.

14882. And for what purpose is the power used?—The power is used for driving the cranes, lathes, blowers and fans at a large pipe foundry, and for running overhead trolleys for feeding the furnaces, and for lighting and general purposes.

14883. Does the blast-furnace gas require to be purified before being used in these engines?—Yes; it is very desirable it should be so to some extent. On the Continent an attempt was made to use the gas for some time by simply passing it through dust-catchers without any washing or purifying operation, but that has been admitted now, by Mr. Greiner, the Engineer of the Company, who adopted this principle, to be unsatisfactory, and I believe he is either converting his existing plant into a plant for washed gas or intends to do so. The plant we have at Sheepbridge is a very simple washing and scrubbing process; the gas passes through the washer, then through a condenser, then through the coke-scrubber, and finally through two saw-dust scrubbers, which purify it sufficiently to enable it to be used satisfactorily in the gas-engine.

14884. Is the cost of the plant great?—The cost of this plant was very low. The gas-engine plant, including the purifying plant, but without the electric plant, cost £1,200.

14885. What would that be per i.h.p.?—About £14 per i.h.p.

14886. What would a steam plant cost?—A steam plant of the same size would cost about £28 per i.h.p., including boilers, seating, chimney, engines and engine house. That is rather an exaggerated comparison, because in the first instance the gas plant was an experimental plant, and was obtained at a much lower price than would be given for a similar plant to-day; and, secondly, because the steam plant for so small a power would necessarily be more costly per i.h.p. than a plant of greater capacity.

14887. If these plants are being extended, the tendency would be to reduce the cost, would it not?—Not to reduce them below the cost of this particular plant. This was looked upon as a pioneer plant, and was supplied at a very low cost by arrangement.

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Mr. Maurice Deacon.

16 June 1903.

14888. (*Professor Dixon.*) There is no difference between the two now?—I think the gas plant would be cheaper than the steam plant now per i.h.p.

14889. (*Mr. Briggs.*) That is where you have the gas provided for you?—Yes.

14890. You do not include the producer?—No.

14891. (*Professor Dixon.*) I meant the producer as against the boiler?—We are talking of blast-furnace gases. I am dealing with the cost of a purifying plant and gas-engines—not of the producer.

14892. (*Sir William Lewis.*) Comparing one machine against the other?—Yes.

14893. (*Chairman.*) Are gas-blowing engines working successfully in the neighbourhood?—Yes.

14894. Then what do you say with regard to rolling mills?—Considerable attention has been paid to utilising the waste heat from both puddling furnaces and heating furnaces. It is a very old practice to raise the steam for driving mills from the waste heat from the puddling furnaces.

14895. There is no method of utilising the heat otherwise than through the steam boiler in that case?—No, I think not. The gases are practically burnt gases, and are only used for steam raising.

14896. You say in some instances fuel has been used with more or less success by the use of the Siemens' regenerating furnace?—Yes, that has been applied to puddling.

14897. That is all with the view of reducing, as I understand, the quantity of coal for a given product?—The quantity, the quality, or the value. In this particular case of puddling it is to reduce the cost of coal, because a small coal is used instead of a large coal. The quantity is not materially reduced, I think.

14898. The use of a cheaper coal would produce the same result?—Yes, quite so; but I do not know that the application of the Siemens' furnace to puddling is really a practical success. It has been adopted in one or two places, but its use does not extend. Its application to heating furnaces is an undoubted success. By its use 50 per cent. of fuel may be saved as compared with the ordinary hand-fired heating furnace.

14899. That is to say you get more out of the fuel?—You get more out of the fuel. You use the fuel in a gas producer, and use the gas in the furnace instead of throwing the coal direct on to the furnace, and wasting a large quantity of the heat.

14900. Has electricity been used in any of the rolling mills?—It has been used a good deal in subsidiary engines, for crane purposes, and so on.

14901. Not for the mills themselves?—No.

14902. No steel rails are rolled with electric power, for instance?—Not that I have heard of. I think the intermittency of the mills, and the variation of the load, so far as present knowledge of electricity goes, is likely to be prohibitive. The load being so very variable, and so intermittent, the generated power would have to be greatly in excess of the load to overcome the maximum load momentarily, and it is highly probable that the cost of such a plant would be prohibitive.

14903. At any rate, you do not know of the successful application of it?—I have not heard of its application anywhere.

14904. Speaking generally, would you say that there is still room at many iron and steel works for a more economical type of boiler?—Yes, I believe there is.

14905. And engines?—Yes.

14906. And that economy would be found by a more general application of condensing and electric plant?—Yes.

14907. (*Sir George Armytage.*) You say you are of opinion that if these collieries were worked on more economical lines, there would be a saving of about 4½ million tons of coal. As Mr. Briggs pointed out, in the case of the collieries which only have a short life to run, you anticipate it would not pay those proprietors to put in more economical plant?—In a great many instances it would not; in some instances it might; it depends upon the circumstances. Generally speaking, a worn out colliery cannot afford to put down new plant.

14908. In consequence of that different order of things, some having a long life, and some having a short life, you have not been able to make any estimate, I suppose, of the pecuniary saving to the colliery owner by these methods?—No.

14909. How would it be possible to induce the present proprietors of the collieries to put in a modern plant, unless you could show there would be some saving to them?—The only inducement to the colliery owner is, that he will derive some financial benefit from it, and of that he must be the sole judge.

14910. He will have more coal to sell?—Yes, precisely.

14911. Generally, I gather you think the greatest economy would be effected by using much smaller stuff in fact you said dust, in the form of gas. Could that not be cheaply applied even to the modern boilers with mechanical stokers, and so on?—Yes, undoubtedly.

14912. Have you made any estimate as to how short a colliery life would pay a man to put in more modern appliances?—No, I have not made an estimate of that sort; it is a very difficult estimate to make; so much depends upon the surrounding circumstances.

14913. It generally depends upon the life of the colliery, does it not? It must do?—It depends upon the life of the colliery and the economy which he would derive from any expenditure he might make upon it. Take a colliery which had 10 years' life, and the fuel was a valuable coking fuel, which he could convert into coke, and make a large profit upon; it would pay him very much better to re-organise some of his plant than in the case of another colliery with 10 years' life whose coal was not a coking coal, but only suitable for selling for common firing purposes. So that it is difficult to lay down any general rule as to what the remaining life of a colliery should be, to warrant a colliery owner altering his plant.

14914. When you say there would be this saving of 4½ million tons of coal, you would hardly mean by that that 4½ million tons of coal would be saved by more economical working?—I do not suggest that you could save 4½ million tons at once. I simply say if the whole of the plant of the collieries in the Kingdom were modern plants of the best description, then the consumption of coal would be one-half what it is to-day.

14915. On the other hand, you say it would not pay many of them to do it?—No, it would not pay them. I put it in that concrete shape in order to call attention to the magnitude of the question, and the strong desirability of adopting the most economical plant. It is only an illustration. I do not suppose such a state of things will be ever reached as to reduce the consumption 50 per cent. below what it is at present. As Mr. Briggs says, the depth will be greater, and the haulage greater; therefore the maximum power will grow; but if by the adoption of mechanical plant we arrest that growth, then we shall obtain the same result which I have pointed to here, which would happen if you were to accept the hypothetical suggestion.

14916. The principal thing you mention in the matter of saving is this mechanical stoker—Schwartzkopff's. Have you any figures from this gentleman, Mr. Evans, or the Middleton Colliery, as to what saving is effected by it?—Yes, but I do not think I have them with me. I have some figures amongst my notes.

14917. (*Chairman.*) Perhaps you could send them to us. If you could put them in, they would be interesting?—Yes; I should be glad to look them up—although I do not think it is a typical plant, by any means—it was put down rather as a rough kind of plant, and I think some improvement has been made since. However, I should be pleased to send you the results of the two plants.

14918. (*Sir George Armytage.*) Apparently you think this one is the best?—Yes, the one at Richard Evans'; it is better put together and more modern.

14919. (*Chairman.*) They are continuing to use it?—Yes.

14920. (*Professor Dixon.*) I understand you to describe the Schwartzkopff stoker, as sending the dust in by a series of brushes?—By a revolving brush.

14921. Is there no current of air used as well, to blow it in?—Yes, there is.

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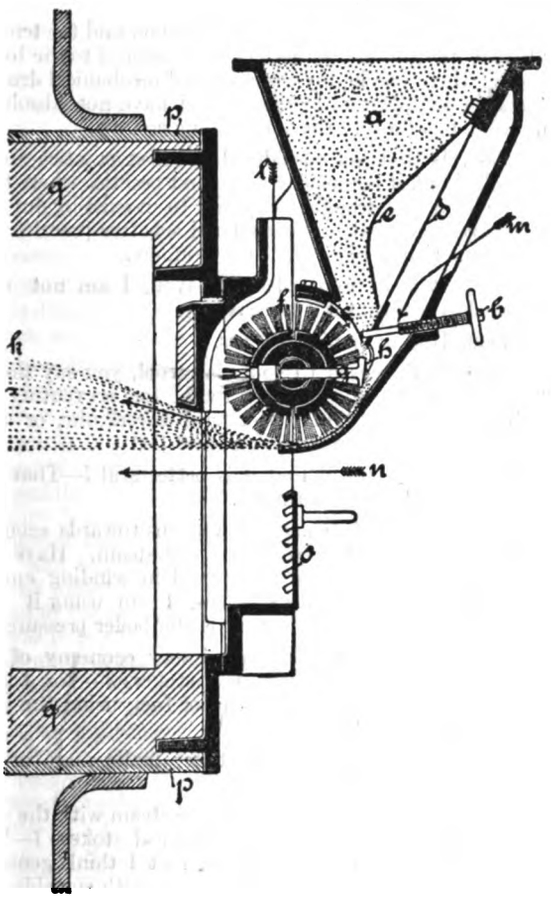
14922. So that practically you have a spray of dust and air?—Yes, that is so. I have a drawing of it here.



A shoot (*a*) receives pulverised coal. It is closed on the bottom by the bent steel plate (*c*) (adjustable by the screw *b*) and the loose flap (*d*). A fixed plate (*e*) relieves the flap (*d*) from the pressure of the powdered coal. (*f*) is a brush, the bristles consisting of steel wires. It carries in the middle the hammer (*g*), which strikes at every revolution of the brush against the nose (*h*) of the steel flap (*d*), and moves the same slightly back from the plate (*c*). As this latter is kept by the screw (*b*) in its position, a slot-like opening is made with each revolution of the brush, through which the powdered coal falls upon the brush. The coal is caught by steel wire bristles and driven into the combustion chamber (*k*). As soon as the hammer (*g*) has passed the nose (*h*), the flap (*d*), owing to its elasticity, strikes back against the plate (*c*). In this manner the contents of the shoot are shaken, and consequently an absolutely regular feeding down of the coal-dust takes place, even if it should be wet.

The combustion chamber (*k*) is formed in the simplest manner; for example, in a flue boiler by lining the flue with fire-bricks for a length of five to nine feet, and providing a fire bridge at the end of this lining. The brick walls (*g*) attain in a very short time the temperature necessary for constant ignition of coal-dust. The first ignition of the coal-dust is affected without any difficulty by a small wood fire or by burning a little old waste soaked in petroleum. A boiler standing all night has the fire properly started in five minutes. The necessary amount of air is introduced to the furnace in the directions indicated by the arrows (*l*, *m*, and *n*) and it is quite sufficient to regulate the admission by the sliding plate (*o*). The amount of coal-dust is regulated during the firing by the screw (*b*). The further the screw is pushed back the wider becomes the distance between (*c*) and (*d*).

During firing only the regulation of the plate (*o*) and the screw (*b*) is necessary and the only other work for the fireman is the removal every ten hours of clinker through the opening at (*n*); one man can attend a battery of twelve boilers or even more. For driving the firing apparatus mechanical power is necessary, equal to only one-tenth of a horse-power.

14923. The air blast runs through with the revolving brush?—Yes, I think it does.

14924. Then with regard to the purifying of the boiler waters. The economical process for softening, which you have described as being very effective, is one dealing with temporary hardness?—Yes. *Mr. Maurice Deacon.* 16 June 1903.

14925. I suppose lime is used in this process?—Yes, lime and soda ash.

14926. Followed by filtering?—Yes.

14927. Would you recommend this process for a water which contains say from 5 to 6 degrees of permanent hardness?—Certainly not.

14928. What have you found most effective in such a case? There are a good many Yorkshire waters of that kind for instance?—I think the Archbutt-Deeley process is the best for water containing sulphate of lime.

14929. Could you describe that to the Commission?—I am afraid I have not gone into it with sufficient detail to clearly explain its action. It is a process by which the water is treated chemically by caustic soda and lime. It has tanks by which the precipitant is periodically stirred up by means of pumps.

14930. Before going into the boiler?—Yes, and the chemical action of the mud stirred up with the water is supposed to purify it in some way or another.

14931. Have you any experience of adding chemicals to the water in the boiler itself?—Yes, I have tried it.

14932. Which have you tried? There are a great number of patented mixtures?—Yes, there are a great many, but I do not much care for them.

14933. Have you tried any of them?—For water containing carbonate of lime I generally use soda ash and lime.

14934. Soda ash containing caustic?—Yes; caustic soda is used in the Archbutt-Deeley process.

14935. Besides the soda ash?—Yes.

14936. You have not any experience of those mixtures used in the boiler?—I have used them from time to time, but I have given them up many years ago.

14937. In your experience are these used for preventing deposits or altering the nature of the deposits?—The boiler compositions, you mean?

14938. Yes,—For removing deposits, I should say.

14939. What I mean is this, you know the deposit comes down in different forms; sometimes it forms a very hard crust, and sometimes it is loose mud at the bottom of the boiler?—Yes.

14940. It is stated that these chemicals, added to the boiler water, will throw down the deposit in a loose form easily removed from time to time. Have you any personal experience of that?—Yes, I think I have found that a scale may be softened by the use of some of them—if the right mixture is used.

14941. You mean it is never deposited as a scale, but comes down in a loose form, to begin with?—Yes.

14942. There are other chemicals used to loosen a scale?—Yes.

14943. In your experience you have found mixtures which will prevent a scale and will throw down the deposit in a loose easily-removed form?—Yes, to some extent I think it is possible if you get the right mixture, but my general experience of mixtures is that the people who supply them do not know anything about it; they supply you with a mixture because it is a mixture, regardless of the water which it has to treat, and I prefer to treat the water before it goes into the boiler.

14944. Your experience coincides with mine. In the case of the boiler which you describe with the incrustations, and with which you made experiments, how often was that cleaned?—That boiler was cleaned every three weeks.

14945. That is very rapid cleaning?—Shocking—very bad water indeed. When I say it was cleaned, it was what was called cleaned. One does not know what that exactly means. Boilers are blown off for cleaning periodically, as you know, and they are supposed to be cleaned, but I should think that the boiler which contained that scale of ½ to ¾ of an inch, was very badly cleaned.

14946. I understand your experience is that for the preliminary treating of a hard water, temporary hardness with lime and permanent hardness with caustic soda, and

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Mr. Maurice Deacon.

16 June 1903.

then some filtering before adding to the boiler, is the most effective ?—Yes, but second-rate to surface condensing.

14947. That is using distilled water ?—Yes.

14948. And in those economisers which you were describing to the Commission, where the steam might be blown through an upright cylinder with baffle-plates in it, the condensed steam would be used over again with the cooling water ?—Yes, although the proportion of condensed steam to water is so small that you do not greatly improve it. You improve it first by using the condensed steam in the small proportion which it bears to the boiler water, and in the second place you get rid of a certain amount of deposit by the process of heating the water in the heater.

14949. Can you tell us about what is the proportion of water required for efficient surface condensing ?—The water required is about 25 to 26 times the weight of the steam to be condensed. To cool that water over and over again, you simply have to make up the loss in evaporation; what that is exactly I am afraid I do not know, but I think the make-up water is somewhere about 15 to 20 per cent.

14950. The warmed water which has been used for cooling being circulated and cooled again atmospherically ?—Yes.

14951. The loss of that is as high as 20 per cent. ?—Well, I am speaking without an absolute recollection of the figures ; perhaps I am a little high—I say 15 to 20 per cent.

14952. Have you any experience yourself of an explosion in a blast furnace in actual working ?—Yes, I have had little explosions—of course from the gas main, not in the furnace itself. It cannot occur in the furnace itself, because the furnace is an incandescent mass.

14953. I understand you to say there is a prejudice against a closed top furnace on account of that ?—Yes. The explosion is in the gas mains always.

14954. That is the main from the top of the furnace ?—Yes.

14955. There was sufficient air mixed with it to make it explosive—or did the air get in accidentally ?—I suppose it would be very largely due to leakage. I am afraid I cannot tell you exactly how it happened, but the air got in somewhere, no doubt.

14956. Such an explosion might happen in any gas plant?—Yes, we have them in our gas engine plant. For that purpose we have an india-rubber disc safety valve in the gas engine house, so that if an explosion occurs it obtains vent there and blows the india-rubber disc out.

14957. I notice that in your evidence you said the loss by radiation, speaking of blast furnace gases, is greater when they are used for steam-raising than when used in a gas engine. Why should that be ?—Because in raising the steam you re-ignite the gas, then you have the radiation of heat in the boiler seatings, and the radiation of heat from the boiler itself, whereas if you use it direct you take it as cold gas to the chamber in your gas engine, when you obtain four or five times as great a duty as under the boilers.

14958. You refer to the loss by radiation after the reburning of the gas ?—Yes.

14959. This silicate cotton you have described is prepared from slag by blowing steam through, is it not ?—Yes, what is called slag wool.

14960. (*Dr. Le Neve Foster.*) You spoke about gas engines, but, as I understand, they are simply used for generating power, principally for electrical dynamos. Have you used any, or thought of using any for winding direct or pumping ?—I have used them for pumping, but I should not like to use them for winding purposes.

14961. Have you ever seen any used for winding purposes ?—No.

14962. Are you aware that there is one in use for winding purposes ?—No, I had no idea that that was the case.

14963. Speaking of the Schwartzkopff method of using powdered fuel, you say you use it in the form of gas. Is that strictly correct ?—Perhaps it is not ; I am not a chemist.

14964. Would it be more correct to say that the powdered fuel is almost instantly converted into gas ?—Probably that is so.

14965. You mention a case in which you said the temperature of the chimney gases had been reduced to the lowest limit. Have you in any cases applied mechanical draught (fans) in the place of chimneys ?—I have not absolutely done so, but I am in the act of doing so now.

14966. Is that not considered the best practice nowadays ?—Well, it is considered the best practice where there is a deficiency of draught as applied to an existing draught. I do not know that it is considered a better practice in a new plant than a high efficiency chimney.

14967. It is in some places ?—Well, I am not quite satisfied myself that it is the case.

14968. It is an opinion ?—Yes.

14969. With regard to your slag wool, you say that is the best substance you have found for preventing the radiation of heat. Have you tried Kieselguhr, or infusorial earth ?—I do not think I have.

14970. I have heard that it is better still ?—That was what was told me in Germany.

14971. (*Mr. J. S. Dixon.*) As a means towards economy you would advocate higher pressure steam. Have you any experience of steam being used in winding engines at from 120 to 130 lbs. ?—Yes, I am using it now. When I say I am using it, that is the boiler pressure.

14972. Have you experienced any economy of fuel by the adoption of mechanical stokers ?—Yes, I have got a better evaporation per lb. of fuel, using the same fuel, than by hand-firing.

14973. Does a mechanical stoker make more or less smoke ?—Less smoke.

14974. Are you able to raise more steam with the same number of boilers by using mechanical stokers ?—With certain types of stokers, yes ; in fact I think generally with any kind of a mechanical stoker, with suitable fuel, you would raise as much steam as by hand-firing.

14975. In many cases of which I am aware the reason for not adopting it is that you require to add to the number of boilers?—I have not found that.

14976. What is about the cost of the repairs to the mechanical stokers?—I have a very unhappy experience of the cost of repairs to mechanical stokers, and I have directed my attention more particularly to these methods of introducing heated air at the back of the bridge which have no moving parts. That is the direction in which the best results are to be obtained.

14977. That is an objection to the adoption of stokers. I think you said you had introduced a central condensing plant which is at work at a colliery now?—Yes.

14978. Is it surface condensing?—A surface condenser.

14979. You prefer that?—I prefer it where I want good boiler water, and, again, where I have not sufficient water to jet condense, and run away ; but for pure and simple condensing regardless of boiler water, and assuming I have sufficient to run away, I should prefer a jet condenser.

14980. There are not so many repairs?—Not so many repairs, and not so much cleaning required.

14981. Generally in regard to the economy of fuel at collieries I suppose the tendency now is to do more and more mechanical work at collieries instead of by horses?—Undoubtedly.

14982. So that the consumption of coal, circumstances being the same, is likely to increase, things remaining as they are?—Yes.

14983. The inducement to the colliery owner is to put down the most economical plant so as to economise as much as possible?—Yes, that is so. That need not necessarily lead to an increased consumption of fuel in bulk, but it undoubtedly is the case, as you say, that the colliery owner is increasing the mechanical power which he uses.

14984. There has been a great deal said about the improvements being made abroad. What is the inducement in Germany to go in so much for central condensing plants, and Schwartzkopff stokers, and things of that kind?—Fuel is of greater value.

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14985. In fact it comes to this, that economies are of greater importance there because of the greater value of the fuel?—Quite so. As I have said, where fuel is worth less than 1s. 6d., with condensing it is practically changed to 1s., unless you want pure boiler water.

14986. Does that apply in many instances to collieries in this country?—To a very considerable extent I think it does.

14987. Take a colliery where there is a washing machine to separate the fine mud from the settlements?—There I should think it would be a question which would be the cheapest, to duplicate the boiler plant or to put down condensers.

14988. Comparing what they are doing elsewhere with what is done in this country, it is a mere matter of pounds, shillings, and pence?—Absolutely.

14989. (*Mr. Briggs.*) You have mentioned the Schwartzkopff stoker. Do you know anything about the Crampton process which used powdered fuel?—No, I do not.

14990. It is a fact, is it not, that nearly 30 years ago the late Mr. Crampton used powdered fuel and tried it with puddling furnaces and boilers? I have an illustration now before me which shows that the introduction was almost identical; it was over a roller instead of a brush, and swept it in. It is rather interesting to know that the difficulty which stopped it was the grinding of the fuel in the same way, and the difficulty of finding fuel that was pure enough; the amount of ash brought in and carried up the chimneys was such a nuisance that only the very best fuel could be used, instead of the worst, and there was the difficulty in grinding. I mention that to show that the same difficulty has arisen, and the same apparatus, or almost exactly the same, was given up for those very reasons you mention. Therefore you do not, I suppose, consider that it is very likely to be an important matter?—No, I do not think so, in this country.

14991. With regard to electric power, which Mr. Brace questioned you upon in reference to the great point of safety; you would rather limit the use of it, I gather, in places where gas is present, to the pit bottom and the intakes?—Undoubtedly.

14992. That would preclude its being largely used for coal-cutting?—Yes. In pits where gas is given off in sufficient quantities to accumulate in the faces, I should certainly hesitate very much to use it.

14993. That means that you are driven back to compressed air?—Yes. By means of electricity you may compress your air near to the spot in a safe place instead of compressing it on the surface and taking it all the way in pipes.

14994. Have you considered the possible economy of doing what I believe is done in Belgium, that is, having one enormous central electric plant taking in the whole of the engines from all the collieries?—Yes, I have considered it, and in laying out a colliery some time ago I had that in my mind in fact. I was rather anxious and thought that I should find it economical, but I found it was not—as applied to winding—therefore I adopted it to all purposes except the winding.

14995. Your idea is a steam winding engine of the best type, and a large power plant of some sort, gas or steam driven?—One or the other.

14996. And then distributing for all other purposes?—Yes, all other purposes. With regard to the coal-cutting I think I might say that by the adoption of the three-phase current you remove one of the serious difficulties which is attached to electrical plant, and which undoubtedly makes the use of electricity in mines very much safer than the continuous current.

14997. There is the danger of the short circuit?—The only danger is the cable and switching danger. The switch difficulty may be got over by placing the switches and fuses in oil. In the three-phase plant I have put down, the fuses and the switches are in oil baths, so that if a spark occurs it is smothered, as it were.

14998. (*Chairman.*) In that case you still put the plant at the bottom of the shaft?—Yes. I have in certain instances taken it inbye for pumping purposes, but I always keep it in the intakes.

14999. (*Mr. Brace.*) You are the Consulting Agent for the Tredegar Company?—Yes.

15000. I think it is at that colliery you have a very complete electrical plant, have you not?—Yes. *Mr. Maurice Deacon.* 16 June 1903.

15001. Would you tell the Commission your experience with that plant, and give us in comparative figures the relative cheapness between electricity and steam?—I can tell it in a few words—or as much as the Commission would probably care to hear—the Tredegar plant is a three-phase plant, which was put down for the purpose of doing away with the old-fashioned haulage, which had got to the end of its tether, and for superseding compressed air, which was used on a large scale, for pumping. I decided to put down a three-phase plant as being the most economical and the safest. With regard to the economy I think, perhaps, I may sum it up by saying that the cost of steam for driving electrical plant, that is, the consumption of steam, is only about 22 or 23 lbs. per i.h.p., whereas the old hauling engines and compressers were no doubt using from 100 to 150 lbs. of steam.

15002. (*Chairman.*) Is electricity used for hauling in that case?—Yes, we have a number of hauling plants. The total plant put down is of about 1,500 h.p. There are five large generators, and about nine separate hauling plants; three large pumping engines pumping the water which used to be pumped at several separate pumping stations, all brought to one point, and a considerable number of smaller pumping engines dealing with separate quantities of water, some in the shafts and some in the workings.

15003. And the total power used is 1,500 h.p.?—About 1,500 h.p.—the total generating power—we are not using the whole of it yet.

15004. What was the comparison of cost, did you say?—The steam used is about 20 or 21 lbs.; we shall get a little better result than that by and bye; the plant is not working on the full load now. The previous steam consumption would not be less than 130 to 150 lbs. per i.h.p.

15005. It is about one-sixth at present?—Yes.

15006. (*Professor Dixon.*) Was the steam brought down from the surface?—Some, and some used in air compressing. Steam was taken down the shafts in some instances to underground hauling engines.

15007. (*Mr. Briggs.*) Have you used any gas-engines with coke-oven gas at all?—No.

15008. You do not know whether that would be suitable enough to use it on a large scale?—I do not think so. I think the volatile gases are consumed in reheating the coke-ovens, and I think you have only the burnt gases.

15009. You have no experience of that?—I have had this experience, that in putting down new plants I have not attempted to use the gas for that purpose.

15010. You use blast-furnace gas?—Yes; we had a little difficulty in the first instance by tar accumulating.

15011. Would you use gas-engines for ventilating fans with a producer or blast-furnace gas?—Yes, I see no objection to that.

15012. Did you use Mr. Thwaite's method of purifying your gas?—Yes.

15013. Your method is one that he recommended to you?—Yes.

15014. (*Mr. Maclay.*) I take it from your evidence that you are inclined to the view that it is to the interest of the country that the collieries should be in the hands of a few wealthy corporations or colliery owners, rather than in the hands of smaller proprietors. That is to say, you think we are more likely to get those improvements you speak about if the collieries were in the hands of a few instead of in the hands of many?—I do not think that that applies very largely. I think, in the natural course of events, all collieries in the future will have to be large collieries; and I do not think, in the type of colliery which will be put down in the future, there will be any difficulty in the matter of finance with reference to the putting down the best appliances.

15015. That is to say that the trade is likely to go into the hands of a few proprietors?—In the hands of fewer proprietors than in the past. That must be so in consequence of the question of depth.

15016. (*Mr. Young.*) You say that one of the reasons for inducing greater economy in the use of coal is the

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Mr. Maurice Deacon.

16 June 1903.

increased cost. Is the capital invested in collieries now greater than it was 25 to 30 years ago?—Well, really that is a very difficult question; I cannot tell you.

15017. (*Mr. Sopwith.*) Sir George Armytage asked you a question as to what inducement was offered to the colliery owner to invest money in order to effect improvements. I have worked it out, and I should like to have your view as to whether this is a fair way to put it. You said there was a possibility of saving about 2½ per cent. upon 5 per cent. I put it in this way: That if for every 100 tons you get two or three tons extra, the amount of saving per ton upon the whole would be about 1d. per ton on the 100 tons. If you assume an average colliery to produce 480,000 tons a year, that would mean a saving of £2,000 upon the output. It would be fair to assume, I think, that in any case you might take three years' purchase on that as being a fair thing for the capital outlay. And, therefore, it would mean this, that if a saving of 1d. per ton can be effected, it would pay an average colliery to outlay £6,000. I think that is rather a concrete way of putting it?—Yes, but I am afraid I do not follow the exact calculations closely enough to confirm it myself.

15018. I will rather put it in this way: I ought to have said in the two or three tons extra that you take, I have taken them at 4s., which is a very fair price for the colliery consumption?—That is rather high.

(*Sir George Armytage.*) I understand your meaning to be that if a colliery had a life of three years, it would pay them to put down such a plant.

(*Mr. Sopwith.*) Not quite so.

15019. (*Mr. Bell.*) What has been the effect upon the value of fine coal by the introduction of mechanical stokers during the last, say, 10 or 12 years? Has it been very material?—Not very material, I think; but it is a very difficult question to answer, because of there being such great fluctuations in prices.

15020. You had formerly more difficulty, I suppose, in dealing with your fine coal than you have now?—I think that is so generally. I think, generally, the small coal is easier to deal with now than it used to be. It is used more largely, either through the greater use of mechanical stokers or for other reasons.

15021. Are you supplying from your colliery to iron-works, or any other industry, small coal to be used by mechanical stokers which have been put in of recent years?—Yes, we are supplying now to an adjoining colliery for use.

15022. The tendency, in your opinion, will be that small coal will be very much more appreciated in the future than it has been in the past?—I think, undoubtedly, it will.

15023. (*Sir Lindsay Wood.*) You gave evidence with reference to the use of furnaces underground. Are not these used now only where they have boiler plant underground?—I should think that is so. There may be a few odd cases; but they are few, I think.

15024. It is not altogether a loss of fuel. If you were to bring your boiler to the surface, you would require a great deal more boiler-power to get the same power at the bottom of the shaft?—No doubt there is an economy in it, but what I referred to was the use of fuel in ventilating furnaces.

15025. Are not the furnaces generally used as a sort of auxiliary to the boiler fires underground?—Of course they would be used where you have boilers underground; but, speaking from past experience, I should say in a great number of cases the fuel was used in a furnace for the purpose of producing ventilation without boilers; and where boilers were underground, of course the heat would be used for the same purpose. In the majority of cases, so far as my experience goes, the fuel was used for the purpose of creating ventilation.

15026. Where you have boilers underground you cannot very well use fans?—No; not the two.

15027. Then with respect to the great saving of fuel by the use of highly efficient boiler power. Is not that only capable of being done by having good water?—Well, you may use high-pressure boilers with bad water, in a manner with a certain degree of advantage; but I do not know that pure boiler water is an absolute necessity to the use of high-pressure boilers; it is a very great advantage, no doubt.

15028. Is it not one of the reasons why they have not been used so much as they ought to have been?—With respect to water-tube boilers that is, no doubt, so. I do not know whether it is the reason why the Lancashire boiler of 150 lbs. has not been used more.

15029. Bad water is of greater prejudicial effect upon the Lancashire boiler than the ordinary egg-end boiler?—Yes, you have the larger diameter of the boiler.

15030. The difficulty is in getting a good purifying plant?—I do not think so.

15031. Is there great difficulty in getting a plant that will purify the water?—I do not think there is any difficulty. It depends upon the water to some extent, no doubt; but I think it is quite possible to purify almost any boiler water that you have to deal with.

15032. At the cost you put?—I think I said from ¾d. to 1½d.; it is possible with very bad water it might be a little more, but I think the cost of softening waters has been cheapened recently. I remember the time when certain boiler waters cost as much as 3d. to purify, but I believe the same waters are done now for about 1½d., and I think 2d., at the outside, would pay for a very bad boiler water.

15033. Is that due to the cheapening of the material used for the chemical process?—Yes, partly due to that, and probably due to the improvement in the plant.

15034. (*Chairman.*) It is automatic, I suppose?—Not absolutely; in some of them there is a pumping plant necessary, but with that exception they are automatic.

15035. (*Sir Lindsay Wood.*) There is also a good deal of difficulty in getting water for condensing plant?—Yes, that is so; but with efficient cooling ponds or towers the difficulty is very greatly reduced. Of course, the financial difficulty comes in again in the cost of cooling ponds and cooling towers.

15036. Altogether, the saving of 4,000,000 tons is rather a problematical thing?—It would be a very long process, I take it.

15037. (*Sir William Lewis.*) Have you made a similar calculation with respect to probable economies in the manufacture of iron and steel to that set forth with reference to the working of coal?—No, I think not, because the economy will be very small; I think there is very little room for a large economy.

15038. Then with reference to the electric plant you put down at the Pochin Pit; do you apply the electrical power at the face in the shape of coal-cutters or pumps?—No.

15039. Not nearer than the bottom of the shaft?—Yes, we have some inbye pumps in the intakes.

15040. Beyond your lamp stations?—Yes.

15041. (*Chairman.*) You gave us some interesting information about the electric plant which Sir William has just referred to. There are two general questions I want to put: Was this the plant put down, did I understand, in substitution for a steam plant already down?—Yes; it was put down originally for auxiliary purposes; that is, to increase the existing hauling and pumping power, and ultimately it was increased so as to supersede the old plant entirely.

15042. How long has it been at work?—It has been at work nearly two years now, I think—eighteen months or two years.

15043. Has the experience of it been sufficient to warrant you in expressing an opinion, or answering this question—as to whether the result has been so satisfactory that it would justify you in repeating the operation by superseding a steam plant with electric plant?—Certainly, under the same conditions.

15044. Would you go further, and say that if you were going to put down a new plant there for a new pit, you would adopt the electric plant?—Yes, with the exception of the winding engines.

15045. But would you do the winding at that pit with it?—No, not the winding; only the hauling.

15046. A word with regard to the water, as I omitted to ask you this question: Is the water that you referred to, containing the 28 degrees of hardness, water which is pumped out of the pit?—No, it is not actually

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pumped out of the pit; it is pumped from a well, and pumped from the same measures, naturally, through which the pit is sunk.

15047. And, naturally, it is similar water to that which is pumped?—It is similar water.

15048. You spoke of the surface condensers and of the cooling towers; are they very costly?—They are rather costly.

15049. Could you give us a sort of idea of the cost per 100 H.P.?—Yes, I have the exact cost here. Of course, it depends upon its construction, because it may be made of iron, steel, or wood; but I think the cost of one of the best, and the most strongly-constructed, cooling towers comes to about 30s. per I.H.P.

15050. Therefore, for each 100 I.H.P. in use, that would be £150 capital outlay?—Yes.

15051. (*Mr. J. S. Dixon.*) That is for the tower alone, not for the whole plant?—Yes, the tower alone. The plant altogether would cost about £2 5s. per I.H.P. *Mr. Maurice Deacon.* 16 June 1903.

15052. (*Chairman.*) That means £220 per 100 I.H.P.?—Yes, £225.

15053. That would be for the cooling tower and the surface condenser?—Yes.

15054. (*Mr. Young.*) You spoke, I think, Mr. Deacon, of ¾d. being the cost of purifying certain water by using certain economisers. Did that include the interest upon the capital, or was it simply for the current cost?—That was the current cost, not including the interest on capital. The interest on capital was only a very small amount—it was only £800 for a very large quantity of water softened—but I think that was the working cost. I do not think the interest on capital comes to more than a decimal point of a penny.

15055. (*Chairman.*) That is ¾d. per 1,000 gallons?—Yes.

Mr. George Beilby, called; and Examined.

15056. (*Chairman.*) You have been good enough to come here again to tell us something about shale oil, in respect to which we have had evidence since you gave yours. You have been connected with the shale oil industry in Scotland for nearly 20 years?—Yes. *Mr. George Beilby.* 16 June 1903.

15057. Now, speaking of oil as fuel, you have had a considerable experience, as I understand, and you use a quantity?—Yes, I have had considerable experience in actually burning oil as a fuel.

15058. I believe that for some years the quantity burned in the works with which you are connected amounted to as much as 6,000 tons?—Yes; 6,600 tons was the quantity per annum for a number of years.

15059. Will you tell us how it compares with coal?—From the point of view of expense, we found that we could afford to pay about ¾d. per gallon for blast furnace oil, as against coal at 12s. per ton. That was for steam-raising purposes.

15060. Would the coal in that case at 12s. a ton, which you have in your mind, have much carriage on it?—Yes, a good deal; it is coal delivered in Glasgow, and the outskirts of Glasgow, and therefore there would be a good deal of carriage.

15061. 2s. or 3s.?—I should think so, probably.

15062. Therefore, under like conditions on the spot, it compares with coal at 9s.?—Yes, probably.

15063. Have you compared a variety of oils, such as blast furnace oil, tar oil, shale oil, and Kimmeridge oil?—Yes. Over a period of more than 10 years I have been using oil fuel for various purposes. In the first instance, this fuel oil was used for furnace work, not for steam raising at all. For particular high temperature furnaces—for heating purposes—it was found to be a suitable fuel, and we could afford to pay a much higher price for it than we could afford to pay for the equivalent of coal for that purpose. As the price of fuel oil rose during the years I have spoken of, it became impossible to pay the higher price demanded for it, and other steps had to be taken to provide another source of heat. This threw upon our hands for a length of time a balance of oil on undelivered contracts which had to be burned somehow, and we took to burning it then under the steam boilers. It is since then that we have had this experience of using oil purely for steam raising; and during that period the experience is what I have already referred to, that with coal at 12s. a ton we do not lose anything in buying the oil at ¾d. per gallon. But during the earlier experience, when it was used for heating purposes purely, we had occasion to use a number of oils, because, as the price of one was too high, we found we could with advantage change to another. Therefore, we have used blast furnace oil, shale oil, tar oil, and the oil from the Kimmeridge Blackstone.

15064. Do you think that any extensive use of oil as fuel is likely to take place?—No, I do not think there is any possibility of it in this country.

15065. What do you think is the greatest bar to it?—The available quantity is so extremely small.

15066. Made in the country?—Made in the country, also the fluctuations in prices are too great. I have had to pay during the last 10 years as much as 3d. per gallon for fuel oil, and on the other hand, I have bought it at ⅝d. With such fluctuations it is impossible to believe that it will come into greater use; the penalty of being caught in a dear year is so serious that the consumer cannot run the risk.

15067. Have you any figures as to the production of oil in Great Britain?—Yes. I estimate that the production of shale oil in the Scotch shale works is about 207,000 tons of tar oil from the Scotch blast furnaces about 150,000 tons, and from gas works and recovery ovens about 750,000 tons—in all about 1,107,000 tons.

15068. What is that used for?—In the case of the shale works it is entirely used for the purpose of refining into purified oils, lamp oils, lubricating oils, and paraffin wax. The entire Scotch output is used for these purposes.

15069. And none of it as fuel?—I did as a matter of fact burn what is called Scotch gas oil for a very short period, because the price happened to be very low; but in the long run it cannot come on the market as fuel, because it would never pay to distil shale merely for the purpose of making fuel oil.

15070. Is it made into lamp oil?—It is made into lamp oil, which to-day is worth about £6 per ton; into lubricating oils, which are worth about £6 to £8; paraffin wax, £25 to £30: and the lowest grade of all, gas oil, is worth from £3 to £4. These prices leave a fair profit, but a drop of 20 per cent. upon them would probably wipe away all that profit. Therefore, quite obviously, there is no reason for the production of fuel oil from this source, because these prices are all immensely above the level of the fuel oil prices.

15071. Are those the prices at the point of manufacture?—No, those are really the prices at the place of delivery—the port prices.

15072. You think this industry is not likely to extend much?—No, there is no room for any great extension. The shale deposits are pretty well ascertained, and the trade has had such a very fluctuating history from the financial point of view that I think it is very unlikely that any amount of new capital will be put into it.

15073. Now what do you say with regard to blast furnaces?—In Scotland I think I am right in saying that with few exceptions all the furnaces using raw coal are recovering tar from the gases, therefore there is not much prospect of any greatly increased quantity coming in from blast furnaces. The blast furnace tar, as recovered from the furnace, is separated by distillation into pitch and oil, and the oil is chiefly used for creosoting timber, and for this purpose has a value higher than the fuel value.

15074. Is the value of the oil or the value of the pitch the greater?—The value of the pitch is considerably greater than the value of the oil.

15075. Per ton?—Yes.

15076. And the quantity produced?—I do not remember the exact proportion. I think, roughly, 50 per cent. of each.

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Mr. George Beilby.

16 June 1903.

15077. What do you say about the gas works and recovery ovens?—There is not likely to be any great extension of gas works, as we all recognise, I think. As to recovery ovens, of course, there is a considerable room for increased output, and it is probable that if any great extension of the use of recovery ovens were to take place, an additional quantity of oil would be available at a price which would enable it to be burnt as fuel. I estimate that in this way, possibly, as much as 300,000 tons might be added to the oil resources of the country.

15078. We have had some interesting evidence with regard to the Kimmeridge shale, as it is called. Have you any experience of that?—In 1886 I went over the ground between Kimmeridge and Abbotsbury on my own account. I wished to judge whether there was any opening for the establishment of a really large industry. Two years later I was consulted by people who had made a beginning in mining and retorting in the Blackstone. On this occasion I remained on the ground for some months. The Blackstone was (mined) at Kimmeridge, and was taken round by boat to Wareham, where a small bench of retorts of one of the older Scotch types had been erected. These retorts were worked for some weeks under my direction. The object of the people who were running this venture was to produce the coke of the Blackstone, which they proposed to sell as a substitute for animal charcoal at £3 to £4 a ton. The retorts at Wareham were very unsuitable for the working of the Blackstone, which was quite unlike Scotch shale in its behaviour. I therefore designed a special retort for the purpose, and a bench of these was erected in Glasgow. The desired product —the coke—was satisfactorily obtained, but proved to be quite unsaleable at any price. The oil which was obtained as a bye-product was also unsaleable, and had, in the end, to be burned as fuel in order to get rid of it. The small quantity of ammonia obtained was not considered worth recovering. The Kimmeridge Blackstone cannot be distilled as cheaply as Scotch shale. The products of distillation are of very inferior value, and could only be used as fuel. The Blackstone contains a very large amount of sulphur. This not only makes the operation of distillation very offensive, but the presence of sulphur in the retort leads to the complete destruction of the paraffin hydrocarbons, so that the crude oil contains no solid paraffin, and is therefore valueless to the refiner. Unless the coke or residue from the distillation had a very high value (which it has not) the products of distillation, the oil and ammonia, are not of sufficient value to pay for the mining and retorting of the shale.

15079. Therefore you do not hold out much hope to us that any extensive production of shale oil will be available for the purposes of fuel?—No, I can see no hope under anything like existing conditions.

15080. Have you considered at all, or do you feel at liberty to express any opinion, as to whether the home product is likely to be supplemented by importing so as to alter that state of things?—It is very difficult to see how it would ever pay to import oil even in bulk at a price such as I have mentioned as the equivalent value of oil to coal—that is to say, at ¾d. per gallon and 15s. per ton. It is very improbable that we shall ever see it. I believe a price of about twice that amount has been sometimes talked of, but I have never been able to buy petroleum at anything like 30s. a ton.

15081. It has been sold at nearly that price in London?—I think it has for a short time.

15082. Are we to take it that, so far as your opinion goes, little reliance can be placed upon oil as a substitute for coal for fuel?—That is my opinion.

15083. And the progress made, with which you are no doubt familiar, as regards the use of oil, for example, for locomotive engines, does not alter in any way the view which you have expressed?—I am not in a position to say what the comparative value of the oil is to the locomotive engineer; how much more he can afford to pay for it than he could for coal. It would need to have a very considerably higher value for him than coal in order to make it a practical question for him in this country on any large scale.

15084. As regards perhaps what I may call the somewhat sanguine views which some people hold as regards the Kimmeridge shale and the oil to be derived from it, I may take it you do not attach very great importance to it?—No: I think any new schemes for utilising the Kimmeridge shale ought to be looked at very carefully and cautiously before they are entered upon. I am sure there is disappointment in store for anyone who goes into that district with sanguine hopes.

15085. And the Kimmeridge clay does not offer even the advantages which the shale in Scotland affords?—No, it is in a different category altogether, because it would be necessary to distil the Kimmeridge shale purely for the purpose of making a fuel oil.

15086. Even although there may be great areas of Kimmeridge clay, the commercial value of it apparently you do not put very high?—That is the case.

15087. (*Sir George Armytage.*) You have used other oils besides; I mean oils from foreign countries?—I have used the residue of American petroleum, and also Russian petroleums in smaller quantities, but they are too expensive to use permanently.

15088. So far as they go oils can be produced in Great Britain at a lower price than you can purchase them from America or Russia?—We can produce the gas tar oils and coke oven oils much more cheaply than I think any oil will be imported from abroad.

15089. Is it as valuable?—It is practically the same. The blast furnace oil has not as high a value as the good petroleum, but that difference is not of very serious moment. It would not enable a very much higher price to be paid for the petroleum than is paid for the best furnace oil.

15090. (*Chairman.*) Is the blast furnace oil used for gas making?—Yes, for the enrichment of coal gas, to some extent.

15091. (*Professor Dixon.*) You promised to give us some information, when you were here last, about the use of large gas engines and producer gas on a big scale. I do not know whether you can do so now?—I have a little more experience since I was here before, but not a great deal. I think the experience is not quite sufficiently complete to present to you in any final form; and, perhaps, on another occasion it might be better.

15092. You are making gas on a large scale?—Yes, we are now making gas with from 80 to 100 tons of coal per day.

15093. What is the particular process?—The Mond system, and the Mond system of washing for recovering ammonia. We are recovering now from 75lbs. to 80lbs. of sulphate of ammonia per ton of coal. The gas is being almost entirely burned under Babcock boilers, because the gas engines in which it is intended ultimately to use it are not yet ready. The experience with the Babcock boilers has been, up to now, wonderfully satisfactory, and it is quite certain, so far as we have gone, that there will be no loss of evaporative power.

15094. Has it gone far enough for you to give us the price per h.p. per hour?—No, I think we must reserve that. I do not think it would be judicious to give that now.

15095. (*Chairman.*) Did I gather you had come to the conclusion that there was no loss of evaporating power?—I should explain myself perhaps a little more fully. I do not mean there is no loss of thermal efficiency, but, contrary to the general expectation amongst engineers, we are able to evaporate as much water per hour in a given boiler with gas firing as we had previously been able to do with coal firing and mechanical stoking. That was rather a surprise, because it had been generally held that gas firing of steam boilers meant that you must increase the steam boiler surface by a certain amount in order to get an equivalent amount of evaporation. It was, therefore, a pleasant surprise to find that our steam boiler would do as much work as ever, when supplied with this gas.

15096. This is gas from coal?—Yes, gas from small coal.

15097. (*Professor Dixon.*) Is there anything particular in the form of boiler you are using?—No, simply large Babcock boilers of the usual type.

15098. Large ones?—We happened to have large boilers, and they responded very well indeed to the new treatment.

15099. The combustion is complete?—Remarkably perfect. The percentage of carbonic acid in the flue gas is 14 to 15 per cent. I cannot give a figure for the

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temperature at which the gases are leaving the tubes and entering the flue, but it is lower than the temperature used to be with the coal firing, which, of course, clearly indicates, along with the carbonic acid, that the efficiency of combustion must be immensely greater than it was with the coal firing.

15100. Do you keep automatic carbonic acid records?—Yes, we keep continuous records.

15101. You get as much as 15 per cent.?—Yes; perhaps we ought to say 14 per cent. as the safer figure—but 14 per cent. without difficulty.

15102. You consider that these records give you a very useful indication?—Very much so.

15103. Are you making any other tests, from time to time, for the amount of oxygen or the amount of carbonic oxide?—Those will follow; we are at present organising a system of testing.

15104. What I meant to suggest was that a continuous working automatic recorder, together with an occasional analysis of the flue gas, might give you very good information?—We have complete arrangements for very frequent analyses of the gas, both the gas burnt and the product of combustion, and all these will be thrown into the form of regular records within a very short time.

15105. If you have a very high percentage of carbonic acid in the gas, and also some carbonic oxide, that would not mean necessarily that you were burning the gas satisfactorily?—Quite so; but I think in this case there is no question of that. No doubt the amount of carbonic oxide is very small.

15106. How long have these boilers been going?—Quite a number of weeks now; I should think six weeks probably.

15107. Have you had long enough experience to see whether the boiler would wear out and would want more repair?—The engineers are entirely satisfied that the boiler will have a very much longer life; they are immensely pleased with the way in which the boiler is behaving. The tubes are remaining perfectly clean, and the result is that the lower rows are doing more work.

15108. Have you pure water?—Yes, we have to purify the feed very carefully.

15109. You had a hard water to start with?—Yes, a very brackish water.

15110. What diameter tube are you using?—I am not quite sure, but they look about 4in.

15111. You cannot give us, I suppose, the comparison between the power produced by these gas-heated water boilers, and what you are getting from large gas engines?—No, I have not the means yet; that must come later.

15112. Now for firing such steam boilers as you are using at Runcorn, do you find it necessary to wash the gas? You are doing it to get the ammonia out?—Yes.

15113. But is it otherwise necessary?—No, I do not think it is necessary. It is much easier on the brickwork to have the gas free from dust; it lasts longer, and to that extent it is worth washing or purifying.

15114. Does the little tar that might get over matter?—That does not matter at all.

15115. Of course, the same answer would apply to the use of Mond gas or other gas, for steel making; it would not much matter there whether you washed it or not?—No. There is an impression, you know, at the present moment that the regenerator stacks suffer if fine dust is left in the gas—that their efficiency becomes reduced—showing there is a loss of thermal efficiency.

15116. Have you any experience of that?—I have not, but I have seen the papers published lately on the subject.

15117. By the lining produced by the dust?—Yes, by the surface glazing, by the dust. It might be interesting on this matter if I were to inform the Commission that I understand a plant has been recently started (only last week) for using washed gas in a large steel works, which has proved eminently successful. Large masses of steel put in cold have been heated with a saving of time already of 25 per cent. Therefore, from that, there is no doubt that washed gas is going to be very successful. The next step, using the washed gas for the melting furnace, has yet to come. That will be complete within three or four months.

15118. Is that an installation of Mond gas?—Yes.

15119. (*Chairman.*) Is that a new application of washed gas?—So far as steel weeks in Scotland go, it is. I think some work has been done in England already, but I do not know the results at first hand; but this really affects one of the large Scotch works.

15120. (*Professor Dixon.*) The price also really depends upon the price of the ammonia?—Of course. There has been a question whether it was possible to do this work with a gas which had been washed and cooled instead of taking the gas comparatively warm from the producers with all its tar in it.

15121. That has been done sometimes?—In England I believe it has, but the Scotch steel makers thought they were making an important step.

15122. The works you refer to are in Scotland?—In Scotland.

15123. (*Dr. Le Neve Foster.*) In calculating the amount of shale produced in Scotland, at what rate have you taken it; how many gallons per ton?—Twenty-five gallons per ton. I think that is about the probable average in Scotland; 30 gallons used to be considered the standard yield, but the era of 30 gallons shale has very nearly passed, and shales are being distilled now, with profit, which contain as little as 18 or 19 gallons per ton.

15124. How many tons did you treat in the experiment you spoke of with the Kimmeridge shale?—Some hundreds of tons; I forget how many now.

15125. Still, it was an experiment?—It was quite a serious and practical trial. It was out of the reach of laboratory work entirely, and the work was continued for six or eight months.

15126. So far as you have gone, has this automatic recorder worked satisfactorily?—Yes, it is working very satisfactorily so far as I have heard. It has been only reported to me by the laboratory chemists; I do not know myself.

15127. I suppose yours is one of the first applications in this country?—I think a good many are in use under a variety of forms.

15128. Which form is yours?—It is called the "Ados" Co., Recorder.

15129. A German one?—It is made and sold in England.

15130. You say you are purifying brackish water. By brackish do you mean salt water?—There is salt in the water.

15131. How are you purifying that?—I am afraid that I am not posted up with the particulars, but I could easily get those for you.

15132. (*Mr. Dixon.*) I want to put one general question to you as bearing upon our inquiry. You hold out no great hopes of saving the resources of the country in coal by the turning of shale into fuel?—I am perfectly clear on that point. There is no chance, in my opinion. It is a very small matter in relation to the coal question.

15133. (*Mr. Briggs.*) In what method do you apply the gas to the Babcock boiler; what sort of burners have you?—The original floor of the furnace (of course the bars are away) is built with chequered brickwork, air and gas being admitted by alternate rows of ports. It comes right up through, and the whole furnace chamber is filled with a mass of flame. The flame only extends to about three or four rows of tubes.

15134. What is the distance of the bottom of the grate from the tubes of the boiler?—We have four boilers at work, and each boiler is slightly different from the other, but I think about 4ft., or 4ft. 6in., is the average distance.

15135. (*Mr. Teall.*) What is meant by "Blackstone"? Does it refer to a particular band of the Kimmeridge clay?—Yes, I think the richest band.

15136. It is a local term well known there?—Yes.

15137. Have you any idea of the thickness of it?—I forget that.

15138. You spoke of the deterioration, and the reduction in the amount, of oil which is yielded by the Scotch oil shales; 30 years ago it was 30 gallons per

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Mr. George Beilby.
16 June 1903.

ton, and now the average is only 25 gallons. Can you say why there is that falling off in the yield per ton?—It is not a falling off in the yield in the same seam; it is that a different set of seams are being worked.—In point of fact these more recently worked shales are

15139. You have no reason to believe that that falling off is due to the fact that they have to go deeper? deeper.

15140. The point is whether you have any reason to believe that that is due to a decreased yield in consequence of the workings having to go deeper. We had some previous evidence that there was a falling off in the yield with depth. I want to know whether you can give any additional information on that point?—No, I cannot.

15141. (*Mr. Dixon.*) Now, I think they are working shale more with an eye to ammonia than to oil?—Yes, that is part of the case; there is the further fact that these poor shales—poor in the sense of oil yield—are very frequently rich not only in ammonia, but in paraffin: that is, the paraffin is often as great in a 20-gallon shale as a 30-gallon shale, because the oil is richer.

15142. Some are not being worked because there is no ammonia obtained?—That is so. I have a paper here upon that subject which was printed some years ago, and which I will hand in. (*Handed.*) *

15143. (*Mr. Teall.*) You have no evidence that the yield in oil falls off simply with the increase in depth?—No, our experience was that it improved rather than otherwise.

15144. Your experiments on the Kimmeridge shale were conducted on a scale that would give very fair practical results to enable you to form a notion of the value of the shale for this purpose?—Yes.

15145. Do you know whether any other experiments of the same kind on the same scale have been made?—Not that I know of. Before I visited Kimmeridge the second time there had been experiments made with the same retorts as those with which I first experimented, and I think a certain amount of shale prior to that time had been sent up to a Scotch oil manufactory and tested there. I think the experiments to which I refer are the only experiments in which hundreds of tons of Kimmeridge shale were involved. I think any others must have been on a much smaller scale.

15146. (*Chairman.*) This occurred years ago?—Yes.

15147. You have continued what I may call increasing your knowledge of the business generally. Do you see any reason, from a commercial point of view, with regard to those Kimmeridge clays to-day, either by reason of the alteration or of the variation in the value of the products, which would lead you to anticipate commercial success now where it failed then?—No, I think nothing has occurred which makes it more likely that the Kimmeridge shales can ever be used for oil purposes. There is the further point that if very large quantities of gas could be used on the spot it is conceivable that these Kimmeridge clays might be worked in some form of producer and used for fuel gas production on the spot; but that would not be as oil fuel.

15148. Do you mean that if gas were found there it could be worked in combination?—No, I mean that if it were worth while to start a very large industrial centre at Kimmeridge it would be worth while calculating whether it would pay to make gas for industrial purposes on the spot from the Kimmeridge deposits. I have not worked that out; I do not think it is very promising, but it is possible that such a thing might be done.

15149. (*Mr. Young.*) Can you say approximately, in millions of tons, what quantity of shale you have in Scotland, say, of the same value that you are now working?—No, I am not in a position to say.

15150. Not approximately?—No, not even approximately. I know the oil companies consider that their present supplies are good for 20 to 30 years, or more, but that is all the length I can go.

Mr. Walter Francis Goodrich, called; and Examined.

Mr. Walter Francis Goodrich.
16 June 1903.

15151. (*Chairman.*) Are you an Associate of the Institution of Mechanical Engineers, author of "The Economical Disposal of Town's Refuse," "Steam Boiler Appliances," etc., and London manager for Messrs. Meldrum, Manchester?—That is so.

15152. During the past 12 years have you had considerable experience of the burning of every class of fuel?—I have of every class of fuel mined in Great Britain and Ireland, as also of a number of waste products from Gas Works, Tanneries and Town's refuse.

15153. Have you devoted a good deal of attention to what I may call the inferior kinds of fuel?—Yes. I have been obliged to do that because our business consists to a very large extent in the burning of inferior fuels.

15154. By some form of forced draught?—Forced draught furnaces.

15155. You have had some little experience of Chinese, Japanese, Indian, Spanish, and French fuels?—Yes.

15156. And you know a number of instances where large British steam users in the East, and also in Spain, extensively employ native fuels, whereas a few years ago Welsh and North-Country coal was exported?—That is so.

15157. I suppose that exported coal costs a good deal more than the native coal?—The freight would add very considerably to the cost of the fuel.

15158. Therefore it was a matter of great importance to use the native fuels?—Yes.

15159. Are you of opinion that in recent years the utilisation of small fuels of various grades for steam raising purposes has steadily increased in England, Scotland and South Wales?—There has undoubtedly been a steady increase now for a great many years.

15160. Would you say that the classes benefited most by that are the colliery proprietors, the coal merchants, and the steam users?—Yes.

15161. I gather that the point is this: that the attention which has been given to the subject, and which has resulted in the utilisation of small fuels of various grades, has raised the price of that grade of fuel very considerably?—Yes.

15162. Therefore it has been a general benefit not only to the producer of it but also to the consumer?—Well, the consumer is now benefiting rather less than the others.

15163. He is using by these mechanical means a fuel which, although it is higher in price compared with what it was a few years ago, is still relatively cheaper than the fuel used formerly?—Yes, that is so, certainly.

15164. I believe you are of opinion that the Railway Companies have done nothing to encourage the use of small fuels, the carrying rates being the same precisely as for the best large coal?—Yes.

15165. While you think that is perfectly justifiable from the carrier's point of view, yet you think it has seriously operated against the utilisation of inferior coal. Another way of stating that would be that if the rates were reduced for the lower sort of fuel it would be still more largely used?—Yes. I meant to convey this: that if a Railway Company was carrying 10 tons of Welsh coal, with perhaps only 1 per cent. of incombustible in it, and the next 10 tons of stuff was very fine (duff), and had 40 to 50 per cent. of incombustible, the user has to pay for the carriage of so much incombustible, which is of no use to him whatever.

15166. Does it cost any less to haul a ton of duff than it does a ton of coal?—I can hardly answer that question. The purchaser certainly has to pay the same.

15167. No doubt the carriage of every article limits the range of its radius proportionately as it bears percentage to its value. That is the point?—Yes.

15168. In other words, a fuel which contains 10 per cent. will go further than a fuel which contains half that?—Naturally.

* Society of Chemical Industry (Scottish Section)—Chairman's Address—30th Nov. 1897.

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15169. You think there has not always been knowledge or wisdom on the part of steam users with regard to the adoption of small and low grade fuel for steam raising purposes?—Quite so.

15170. In what way do you mean that?—Well, I really meant that the average British steam user was anything but scientific; he does not trouble to ascertain the prices—the comparative calorific value of the various classes of fuel. He will state frankly that Welsh coal is the best, and if you were to tell him that slack from that same coal was almost as good, and perhaps would have a value of only 500 British thermal units less, he would not believe it. He thinks because it is small it is necessarily no good. It is because the average steam user has not gone scientifically into the matter.

15171. The only cure you think for that is to conduct a works in such a way as to prove to them the value of small fuels?—Certainly. The fuel should be largely bought by analysis. That is what is done in many large works now. They employ a chemist, and they buy fuel by analysis, and in such cases they have clearly proved the value of small fuels.

15172. You mean that they buy it with the knowledge of what the analysis tells them. That is what you mean, or do you mean it is possible now to buy coal—make a contract for coal—in which the contractor guarantees you a certain analysis?—What has been done in one or two large works in Yorkshire is this. When they are requiring 5,000 tons of coal, say over a period of three months, they invite tenders and ask for samples; day by day two or three samples are taken from each truck, or perhaps more, and those are analysed. and if the various analyses day by day do not keep up to the official analysis—that is, the analysis when the purchase was made—the coal merchant very soon hears of it.

15173. (*Sir George Armytage.*) What is the character of the analysis?—The analysis would only show just the calorific value; the volatile and the incombustible matter analysed by calorimeter.

15174. And the practical analysis as to the quantity of water evaporated?—Yes, certainly; that they are doing always.

15175. (*Chairman.*) The remedy is to terminate the contract if it proves that the bulk does not equal the sample?—I do not know whether they are able to adopt such drastic methods as that with the coal merchant, but they are certainly covered to a definite extent. The agreement is such that they are able to get such coal cheaper.

15176. (*Sir George Armytage.*) They cannot do that without the consent of the seller of the coal?—That is in the agreement.

15177. You have not got a copy of an agreement of that sort?—I have not.

15178. (*Dr. Le Neve Foster.*) Can you get us one?—I will endeavour to do so. Some of the large companies do not like to give one information about what they are doing in the way of fuel cost.*

15179. You say small and low-grade fuels have been condemned by steam users simply because it was found impossible to efficiently burn such fuels under precisely the same conditions, and with the same apparatus, as was found suitable for large fuel of a higher calorific value?—Yes.

15180. That, of course, is the general want of knowledge on the part of the steam user?—Yes, it would be owing to a general want of knowledge. Take such a case as this: A steam user, at a time, perhaps, two or three years since (there were many such cases when Welsh coal went up to a tremendous price), naturally wanted to try and use the cheapest fuel he could get, so as to avoid using Welsh coal, but still not to spend any money on special apparatus for burning the coal; when he came to purchase some of the small cheap fuels that could be obtained in London at that time, such, for instance, as coke breeze costing one quarter of the price of the Welsh coal, he found it impossible to burn it efficiently under existing conditions. Consequently he said at once that coke breeze was of no use. He would not go to the trouble of looking further into the matter, or to the expense of putting down any special apparatus for burning coke breeze, but condemned the fuel as being unsuitable for use at all.

15181. Do you think that small fuel is not necessarily inferior?—Certainly not. I have a sample of fuel here of slurry or pond settlings mined at North's Navigation Collieries, South Wales, with a calorific value of 13,436 British thermal units. It is all fine dust, like flour. (*Producing same.*)

15182. Is that on sale?—They are burning this at the colliery. You could scarcely have a more remarkable example than this.

15183. (*Mr. Brace.*) What is the comparison between that and large?—Well, the finest Welsh coal would have about 15,000 British thermal units. This has 13,436, and, curiously enough, the percentage of ash is only 4·5 per cent.

15184. (*Mr. Young.*) Is it ground?—No, it is just fine stuff—pond settlings.

15185. (*Chairman.*) Is there much of that made?—Yes, a very considerable quantity.

15186. Is it used locally?—They are not able to use all of it; but they are selling very considerable quantities of washed fuel.

15187. Is that used for making into briquettes at all?—Not to any great extent. Unless it is used with forced draught it is absolutely worthless.

15188. (*Mr. Teall.*) What is the difference in price between this and the large? There is only a difference of 10 per cent. in thermal efficiency?—I should like to put it in this way, not being familiar with the cost of Welsh coal at the pit just now; I should fix the selling value for the surplus at 1s. per ton.

15189. Of the stuff which you have there?—Yes, of the stuff which I have here. There is plenty of that to be obtained at a cost of 1s. per ton.

15190. (*Sir William Lewis.*) Do you suggest to the Chairman that that can be obtained from North's Navigation Company for 1s. per ton at the pit?—I would not like to bind myself to say that North's Navigation Company could supply any quantity at 1s. per ton, but I would say that similar material can be obtained at many places. I do not know what quantity North's Navigation Company have to dispose of, but I know they have a surplus.

15191. (*Chairman.*) Do you know of any contracts that have been made at 1s. per ton?—No, I do not.

15192. You express an opinion that it can be bought at that price, therefore you found that upon something?—Well, I have heard of its being used in the district, costing about that price.

15193. (*Sir George Armytage.*) I see on this piece of paper which was attached to the sample the words "thrown away?"—I have not examined that piece of paper.

15194. It says: "Slurry or pond settlings thrown away"?—They were previously thrown away before they were burned with forced draught furnaces.

15195. This is dated November 6th, 1902. Does that mean they were thrown away in November last year?—Yes, it is quite possible. At that time we were asked to analyse the fuel. This sample came from our laboratory only this morning. I have not looked at these samples, therefore I can hardly answer any question that you may put arising out of what is written on the papers.

15196. Do we understand that the calorific value of this is about nine-tenths of the best Welsh coal?—Yes.

15197. (*Chairman.*) You do not know to what purpose it is applied now, except that it is burned in certain collieries in boilers?—I know we have supplied furnaces to a number of firms in South Wales who are buying it in small quantities from the collieries.

* 10th August, 1903.—I have been unable to procure a copy of the agreement between our clients and their Coal Merchants, but I have verified my statement, *i.e.*, that coal is purchased on analysis, and that constant analyses are made to determine the calorific value of the fuel supplied, and to ensure the quality of the supply being kept up to the purchase standard. I have further ascertained that it is now practically impossible to purchase any fuel on such a basis in London and the South, although there is frequently a desire to do so owing to the fluctuation in quality even with expensive fuels.

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Mr. Walter Francis Goodrich.

16 June 1903.

15198. How many firms do you refer to? Do you mean to colliery owners?—Apart from those in various industries; but, as I said just now, the quantity of this material available is entirely governed by the quantity of fuel washed at the colliery. At some collieries I believe no fuel whatever is washed; they do not sell any washed fuel, therefore the waste they have is of an entirely different character.

15199. You have put up quite a considerable number of your furnaces in different parts of the world?—Rather over 12,000 now, burning 8 to 10 million tons of coal per annum.

15200. Generally speaking, do they give satisfaction?—Yes.

15201. Do you specially design the furnaces for the particular kind of fuel which it is intended they should burn?—To some extent.

15202. There is no common plan?—No, we have no standard furnace that will do for dealing with 20 different fuels.

15203. What is the principle of the furnace?—We should make a difference in the air supply, and a difference in the air space of the fire bars, to suit different classes of fuel after we have tested them.

15204. Is it a steam jet?—A steam jet blower.

15205. Do you say at this time three-fourths of the gas works in Great Britain, and a very large number abroad, are fitted with your furnaces?—That is so. We first turned our attention to the utilisation of gas works breeze and coke dust, and we found that by the application of forced draught combined with a specially designed furnace and fire bars, that this material which was previously wasted was capable of being efficiently used for steam raising purposes.

15206. And you say that the result is that inferior fuels are used, and the whole of the coke produced is now available for the market. What do you mean when you say that the whole of the coke produced is now available for the market?—I mean that they are able to get steam in gas works to which we have applied our furnaces, from the coke breeze, pan breeze, and the coke dust, and therefore they have the whole of their output of coke available for the market; whereas before they adopted forced draught they used to burn a certain proportion of the coke for keeping steam.

15207. Instead of the small stuff?—Yes.

15208. What is the pan breeze to which you refer?—The pan breeze is some of the very worst of the material that drops through, or rather that they get out of the retorts. It consists of a very large percentage of clinker, sometimes as much as 60 per cent.

15209. And is that of much value for fuel?—In some cases gas works now produce a considerable quantity of high pressure steam from pan breeze alone. In one or two cases, I might mention, we have used up immense accumulations, some of which have been accumulating for three or four years. For instance, at Guildford gas works we have used up two years' accumulation of pan breeze, and that lasted five or six months.

15210. When you speak of clinker, there is not much fuel in that, is there?—Very little; you will find perhaps a small proportion of fuel that has become fused in.

15211. Can it be burned with the other?—We burn out all the fuel mixed in with the clinker; that is, the small particles of fuel which have become fused on the outside. The reason of putting that in is because the fuel would hardly pay to sort; besides, there is a certain proportion of combustible fuel embedded in with the clinker.

15212. You say that at collieries in South Wales, the Midlands, Derbyshire, Yorkshire, Durham, Northumberland, Lancashire, Scotland, France, Belgium, the Transvaal, and China, low grade fuels are being burnt, thus leaving the maximum of good quality coal available for the general market. You mean being burnt at the collieries?—At the collieries in their own boilers.

15213. And in Great Britain quite a large number of low grade fuels are used, including coal dust, duff, smudge, shale, and brasses—what are brasses?—Brasses is a fuel which contains a considerable proportion of stony matter—earthy matter. It is quite a local name.

15214. Anthracite culm, gum, washery refuse, are also used?—Yes, the washery refuse is similar to the sample which you saw just now.

15215. Have the Wigan Coal and Iron Company a number of your furnaces?—I believe we have fitted over 60 furnaces for them now.

15216. Have they been in work some time?—Some have been in use five years.

15217. Are they mainly fired with refuse from the coal washing machinery?—That is so.

15218. And until about five years ago the whole of this refuse fuel was tipped to waste?—Yes.

15219. You mention Messrs. Crawshay Brothers at Cyfarthfa, the Marquis of Bute, the Tredegar Coal and Iron Company, and a great many other collieries where your furnaces are in use, including some in France. You have in some of these very large installations?—Yes; Messrs. Crawshay Brothers have been using our furnaces now for, I think, rather more than 10 years, and we still occasionally fit furnaces to new boilers for them as they instal them.

15220. These are all steam boilers for raising steam?—Yes.

15221. Then you refer to the specimens of low grade fuels which you have produced. You have told us about the analyses, and then you describe in a table which we will put in quite a number of coke dust settlings, and so on—which you have had analysed, I suppose?—Yes. Those are just a few selected from our laboratory records. I merely included them so that you might see what a high calorific value some of the low grade fuels have. Here is the table—

TABLE showing Analyses of certain Inferior Fuels.

——	——	Calorific Value.	Volatile Matter.	Incombustible.	Moisture.
			Per Cent.	Per Cent.	Per Cent.
Park Coal Company, Mirfield	Coke dust and coal dust.	10·2	22·96	22·23	—
Nunnery Colliery Company, Sheffield.	Pond settlings from tip	10·3	27·43	16·06	—
Low Moor Company Limited, Bradford.	Tank settlings	5·75	20·63	20·66	10·5
Aldwarke Main Colliery, Rotherham.	Pickings	10·8	35·5	24·066	—
Morley Main Colliery Company	Bottom hub	7·1	41·6	42·	—
Nunnery Colliery Company, Sheffield.	Pickings from screens	8·5	24·075	36·6	—
Nunnery Colliery Company, Sheffield.	Coal washery refuse	5·1	17·125	54·66	—
Nunnery Colliery Company, Sheffield.	Pickings	13·0	35·16	9·23	—
Fryston Colliery Company	Fine washings	8·19	39·36	38·9	—
New Charlston Colliery, Normanton.	Washery refuse	10·28	—	11·3	11·4
New Charlston Colliery, Normanton.	Pond settlings	12·04	—	0·78	40·2
Woolley Colliery Company	Pond settlings	11·66	21·125	17·4	—
Crawshaw and Warburton, Dewsbury.	Shale	4·45	27·03	56·63	—
Neepsend Gas Works, Sheffield	Fine coke dust	9·4	4·3	13·5	—

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GLASSHOUGHTON SHALE.

This is shale of very poor quality (mined by the Glasshoughton and Castleford Colliery Company) as will be seen from the following analyses :—

(*a*) Shale—size, 3" squares :

Calorific value - -	1933 B.T.U. per pound.
Volatile matter - -	16·60 per cent.
Ash - - - - -	11·6 per cent.

(*b*) Shale—size, 6" squares :

Calorific value - -	2416 B.T.U per pound.
Volatile matter - -	20·16 per cent.
Ash - - -	63·80 per cent.

(*c*) Shale—size, 3" squares :

Calorific value -	6573 B.T.U per pound.
Volatile matter -	23·73 per cent.
Ash - - - - -	19·43 per cent.

15222. One appears to contain 40 per cent. of moisture, 12 per cent. calorific value, and only ·078 of incombustible. I suppose that was taken wet?—Yes, that would be taken out wet just direct from the pond. In some places this material is exposed to the air for a very considerable time before it is used, and it is practically in the condition of powder, much the same as the sample which you saw just now.

15223. How can you deal with it if it contains 40 per cent. of water?—You could not spread such fine stuff?—As a matter of fact, I have very often seen smudge and culm in Scotland very heavily slaked with water in the summer time to hold it together, so that they could fire it better by getting it in the form of mud rather than in the form of dust. I should think they would sometimes add as much as 40 per cent. of water in that way. It has a coking effect, and holds it together very much better.

15224. You speak of Glasshoughton shale. Is that Glasshoughton in Yorkshire?—Yes.

15225. Is that much used for fuel with your plant?—Well, this is the first installation of that particular kind. In this case we designed a furnace on the lines of our refuse destructor, so as to give a very considerable grate area outside the boiler, and it has been remarkably successful there, so successful that we have three or four other such furnaces in hand now for different parts of Yorkshire. Being such a low grade fuel, with such a high percentage of incombustible, it needs rather more grate area to burn it than is provided in an ordinary Lancashire boiler. That is, if we take a Lancashire boiler 8ft. in diameter, you would get a grate area of 36 square feet. We can easily put 50 and 75 square feet of area outside. Passing the gases directly through the boiler, we are able to burn so much of this low grade fuel that we get practically the same results that would be obtained from burning Welsh fuel in the boiler itself. Now at Glasshoughton, for instance, we are evaporating as much as 1,000 gallons an hour from one of the boilers. There are few boilers in London to-day giving that duty from Welsh coal. The explanation is that there is a very large grate area, and that the fuel is burned externally to the boiler.

Supplement. Plate 20.

15226. And with forced draught?—Yes. I believe the utilization of some of the lowest grade fuels is likely to develop along those lines rather than burning the material in boilers.

15227. You give in case (b) a calorific value of 2416 B.T.U. per lb. The volatile matter is 20·16 per cent., and ash 63·80 per cent. That is a very high percentage of incombustible, is it not?—Yes, comparing that with the other two, I am inclined to think that we must have come across a particularly bad specimen.

15228. Then you refer to some interesting examples showing the value of some of the immense colliery refuse tips in the Black Country. You say that early in 1901 Messrs. Holt and Willetts, chain makers, of Lion Works, Cradley Heath, purchased a plot of land adjoining an old worked out colliery. That is where a firm bought a plot of land and put down their works in the neighbourhood of large heaps of refuse?—Yes.

15229. I understand that you fitted your furnaces to two Lancashire boilers, with the result that they were able to use this refuse?—Yes, I have a sample of that fuel here. Previously they had been fired with slack costing 6s. 6d. per ton, now they burn refuse only. We analysed a sample from the heap on June 4th last, and it gave the following result :—Calorific value, 8216 B.T.U. = 8·5 lbs ; volatile matter, 36·98 per cent. ; incombustible, 23·1 per cent. It was a shaley slack and 60 per cent. of it was under ½" in size.

15230. You point to it as being a mine of wealth. Do you think that these mounds exist in a great many parts of the country?—I do not know that they do in many parts of the country, but I know they exist in very great numbers in the Black Country, and they are mostly of this composition.

15231. Do you estimate that the fuel value of one heap is at least £20,000?—Yes, that is Messrs. Holt and Willetts' estimate, and they believe it will last them 40 years.

15232. They use 27 tons of it per week?—Yes.

15233. (*Mr. Bell.*) What do they do with it after converting it into fuel?—It is burnt in their steam boilers—two Lancashire boilers.

15234. (*Chairman.*) They have erected a factory?—Yes, they are chain makers.

15235. (*Mr. Bell.*) They erected a factory near the heap for the purpose of using the heap?—I cannot say what they had in their minds at the time, but they built the factory near the mounds, and they are just using up one of them instead of burning slack at 6s. 6d. per ton.

15236. They get it for nothing?—They get it for nothing, and I think the plot of land only cost some £300.

15237. (*Chairman.*) You give us examples of former waste being put to valuable account in specially designed furnaces ; for instance, clinker and cinders from Messrs. E. and J. Richardson's Leather Works. Elswick, calorific value, 1836 B.T.U. per lb., incombustible, 83·3 per cent. Does that mean clinker and cinder made by them in former times?—It simply means the residue from the boiler fires ; that is, after the man has burnt a charge of fuel down in his furnace he cleans his fire out and puts on a fresh charge of fuel. This is what he takes out. It shows fuel imperfectly burned and removed too quickly.

15238. Then you give a somewhat similar experience of cinders from Messrs. Naylor Brothers, Huddersfield, with a calorific value of 4640 B.U.T. per lb., incombustible 52 per cent., and cinders from the Manchester Co-operative Wholesale Society, Middleton Junction. These analyses are made by you?—Yes.

15239. The calorific value at the Manchester Co-operative Wholesale Society, Middleton Junction, is 6090 B.T.U. per lb., and actual incombustible, 55·06 per cent.?—Yes.

15240. Then, I suppose in this case you have put in one of these mechanical stokers?—No ; this is refuse from a mechanical stoker of the helical type not made by us. We are using these very excellent cinders for the purpose of effecting the cremation of a large quantity of waste from the preserve works.

15241. (*Sir George Armytage.*) They practically only half burn it there?—Well, that is what it amounts to on the analysis. The figures of these analyses can all be depended upon, because they are arrived at in our laboratory, and they are figures upon which we have given guarantees.

15242. Is *that* stuff the same as it came out of the pit hill?—It goes into the laboratory just as it comes from the heap ; there is nothing taken from it.

15243. (*Mr. Young.*) Was that analysis made for the Co-operative people at Manchester?—No ; it was an analysis which we made for our own guidance. We were asked to design a small refuse destructor for burning the fruit refuse. This fruit refuse consists of a large quantity of sloppy material—in fact, some contains 90 per cent. of moisture. Naturally, we need some secondary fuel to get up the temperature. If there were no such material as this available in the works—that is, good refuse from the boilers—it would mean that they would have to purchase coke breeze or

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Mr. Walter Francis Goodrich.

16 June 1903.

coke, in order to use it in connection with the destructor. In every case where we are called in to do that we always ascertain what proportion of combustible waste they have on the premises in the way of cinder, and so on, from the boilers, and we analyse it for our own guidance, so as to know what to recommend. In most cases we find we can get sufficient of this combustible material, that is really waste from the boilers, to burn a very considerable quantity of very vile material.

15244. Did you make a destructor for the Co-operative people?—Yes, we put up three for them.

15245. (*Chairman.*) You speak of the Castlecomer coalfield in the Kilkenny district, in Ireland, where you say there are enormous quantities of anthracite coal available. Is that being got in any large quantities?—Well, I think I can give the figure there. So far as I can arrive at it, 100,000 tons per annum is what they are mining from that district.

15246. You estimate that there are 80,000,000 tons of workable coal in the Castlecomer area?—That was a figure given to me by a gentleman interested in one of the collieries when I was three three or four years since. I went round to see a number of the collieries at the time.

15247. What is the anthracite coal used for there?—It is used for various purposes. I went to one or two workhouses, and saw them burning it in their fires; I saw them burning it at the asylum, and also in several cases with steam boilers. I am told quite a number of people are burning it there for house fires. I was living in Scotland at the time, and I got them to send me up about a quarter of a hundredweight of it, and it is remarkable fuel; you can light it in a fire in the morning and leave it till bed-time, and if you leave it alone, you will get a bright fire for 12 to 16 hours.

15248. Then what delays its development?—There are no means of transit.

15249. Are there no railways in Ireland?—There are railways, but there is no railway, I think, within 20 or 25 miles of this coalfield. At the present time it is taken by road, and such a method of transit naturally adds to the cost so that it cannot compete with railborne English and Scotch coals.

15250. You give us, as I understand, the information as it was given to you?—I took the trouble, when over there, to investigate it. We were fitting up a number of furnaces in the Kilkenny district to deal with the fuel. I had to go over upon the matter, and it seemed to me to be of such importance that I spent a little time investigating it, and I have given you the result of my investigations.

15251. You say that at the Durrow Brick Company's works, Durrow, Queen's County, this Castlecomer anthracite slack is used for steam-raising purposes, being burned in Lancashire boilers fitted with forced draught furnaces; this company pays 1d. per cwt. for this small fuel at the mine, carting the same themselves. That is not very dear?—It is a very low price for a very fine fuel.

15252. And you say that at the works of the Athy Brick and Tile Co., Athy, similar results are obtained. Does any of it go to Dublin?—I do not think so. I have never heard of any going to Dublin. In some few cases in the district, where steam is required, this fuel is used with uniformly good results, and although I had occasion to look exhaustively into the matter, I could discover no reason why such fuel should not be employed even so far away as Dublin (some 80 miles) except the difficulties of transit.

15253. Is Dublin the nearest large city?—Yes; there is no city of any size between that district and Dublin. Of course, Kilkenny is only a small place.

15254. You think there is also some fuel in the Dungannon district, County Tyrone?—Yes. I had an opportunity of looking into the fuel question up in County Tyrone four or five years ago.

15255. Is that as good as the other one?—No, it is very inferior fuel. We analysed some samples of slack from Dungannon Collieries, and we got as much as 55 per cent. of incombustible.

15256. Is any of the coal that you refer to used by the railway companies in the neighbourhood, do you know?—I do not believe it is.

15257. You say that Messrs. J. and P. Coats, Limited, of Paisley, have some thread mills at Torello, near Barcelona. Are they using the Meldrum furnace there?—Yes, they have been using our furnace for about five or six years on five large boilers, and they use low grade Spanish fuel.

15258–9. And satisfactorily?—Quite satisfactorily.

15260. Are those the large thread manufacturers?—Yes, they have something like 60 large steam boilers at Paisley.

15261. Also fitted with your furnace?—No; we have not fitted the whole of the boilers at Paisley, but we have fitted them abroad, in St. Petersburg and Spain.

15262. Does that mean that they get coal so cheap in Scotland that they do not need any economising in the way of furnaces?—No.

15263. Have you any at work in Scotland?—We have many hundreds at work in Scotland.

15264. In the result, you offer a few suggestions making for economy in fuel consumption. You would say, use up every heap now above the ground, and make full use of all inferior fuels which are below, in so far as these often have to be handled to get out the better qualities. You mean the small coal left underground?—Yes; a lot of the small inferior stuff and dust. We understand that there are very considerable quantities in some parts of the country.

15265. That is rather general. Well, if I might point more particularly to one place than another, I would say in the West of Scotland.

15266. Do you think that there is a difference between good firemen and bad firemen?—Oh, yes; a very remarkable difference.

15267. What is it makes a good fireman?—We find that some of the best fireman that we can get hold of nowadays are men whom you might take from the field or plough—a man who knows nothing whatever about fuel. A man of that kind has nothing to unlearn; he is willing to be instructed. If you give him a certain class of fuel to deal with, and tell him how to deal with it, the man will do his work properly; but if you have a man who has spent, perhaps, 15 years in His Majesty's Navy on one of the battleships, and has been used to firing with Welsh coal, you can never get him to do it in any other way, and he very much resents being told to do it in any other way. We find, therefore, that the best man is one who knows nothing about fuel or firing beforehand.

15268. You are a great believer in analyses, apparently. You say the large steam user would be well advised to institute a system of analyses of the residue; this check on the operations of the firemen would pay handsomely, and you think that would reduce waste to the minimum. Do I gather from that, that the ashes, as we call them, should be analysed from time to time?—I would have a daily analysis. I can give you examples showing the cost in pounds and shillings of the fearful waste. For instance, here in London a large firm of confectioners burn something like 150 tons of coal per week, having 20 tons available per week now of cinder and ash from their boilers. They have been making up ground with them for years, and raising the level of the ground round about their works. They have recently called us in to build a special furnace and put down a boiler with which to utilise those 20 tons of fuel for steam purposes.

15269. That you are doing?—We have not commenced yet; we have the work in hand.

15270. (*Dr. Le Neve Foster.*) Have you any domestic furnaces?—No, nothing of the kind.

15271. Destructors?—Yes, refuse destructors, mechanical stokers, and forced draught furnaces of various kinds.

15272. The great difference between your furnace for burning small coal and the Schwartzkopff is, you are using steam injection and they are using no steam?—We are using steam-jet blowers. That has been our principle from the start.

15273. Must the coal that you use be fine?—No, we can burn anything up to the largest Welsh coal. We

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can design our furnaces accordingly. In many places we are burning large Welsh coal, where people are requiring to get a considerable output in steam from their boilers. We have a very considerable amount of work in hand from time to time for cases such as that.

15274. What is the greatest percentage of ash which is allowable? We have heard up to 65 per cent. Can you go beyond that?—I think in a destructor furnace. designed on the lines of the one that we have built for Glasshoughton, in Yorkshire, and of which we have two or three others in hand, you might go up to 75 per cent. of ash—75 per cent. of incombustible.

See Supplement. Plate 20.

15275. How much ash is there in that stuff that you were showing us from the pit heap in Staffordshire?—That is Holt and Willetts, 23·1 per cent. It is very remarkable.

15276. Not more than that?—Not more. I had this sample taken only about a fortnight ago for the purpose of the Commission, so that you might see exactly what the material was now, because it is two or more years since they commenced to burn it. Naturally, as they get into the heap it may change, to some extent, in composition.

15277. The average ash heaps will have a large proportion?—Some might run to 50 per cent. This sample is remarkably good.

15278. (*Mr. J. S. Dixon.*) Your furnaces are worked by driving in steam and air?—Steam jet blowers.

15279. How much steam do you use in proportion to the production of the boiler?—If we assume that a Lancashire boiler 8ft. in diameter is evaporating 700 gallons per hour, we would use 3 per cent. of that steam for providing the draught.

15280. Not more?—No.

15281. Do you know of forced draught being produced by a fan?—Yes.

15282. That is being done as well?—Yes, that is being done to some extent, but it has not been at all extensively adopted in connection with steam boilers. There is a distinct difference between that and putting air into the front under pressure.

15283. Induced draught by exhausting?—Exhausting—the fan is on the other side of the boiler.

15284. Have you any instances where you raised steam by burning house refuse, ashes, and so on?—Yes; we have erected just over 50 destructors during the past five years for that purpose alone, and in almost every case for raising a considerable quantity of steam from the refuse, for sewage pumping, water pumping, electric lighting, electric trams. We have several installations of that kind in hand now.

15285. You do not burn it in boilers?—Yes, I have one or two cases in the London district, one down at Epsom, where we are burning about 2 tons of house refuse, instead of coal, per day, in a Cornish boiler.

15286. You state that in the West of Scotland there is a great deal of small coal left underground. We have had evidence here that that is not so; therefore, I should like to know your source of information?—I can only tell you what I have heard, I have not been underground myself.

15287. I may assure you that the whole of the coal is put out in Scotland, they work the large and the small small. You should not repeat that statement, because it is not the case.—I am very glad to know I am wrong.

15288. (*Mr. Sopwith.*) You were speaking of house fires for anthracite. What size do they use for burning in grates with the Irish coal you were speaking about?—I believe it is usually broken up into about 4in. to 5in. cubes.

15289. Do you know the analysis of the Irish anthracite, the amount of carbon, and the volatile hydrocarbons?—If I remember rightly, it is somewhere about 88 per cent. of carbon.

15290. You find that that burns in an ordinary grate without any forced draught?—Yes, I found several examples of that myself.

15291. And the coal is the ordinary coal that comes out of the pit?—Yes, and comes from no very great depth.

15292. You are quite sure about the amount of fixed carbon being 88 per cent.?—I will get the actual figures.*

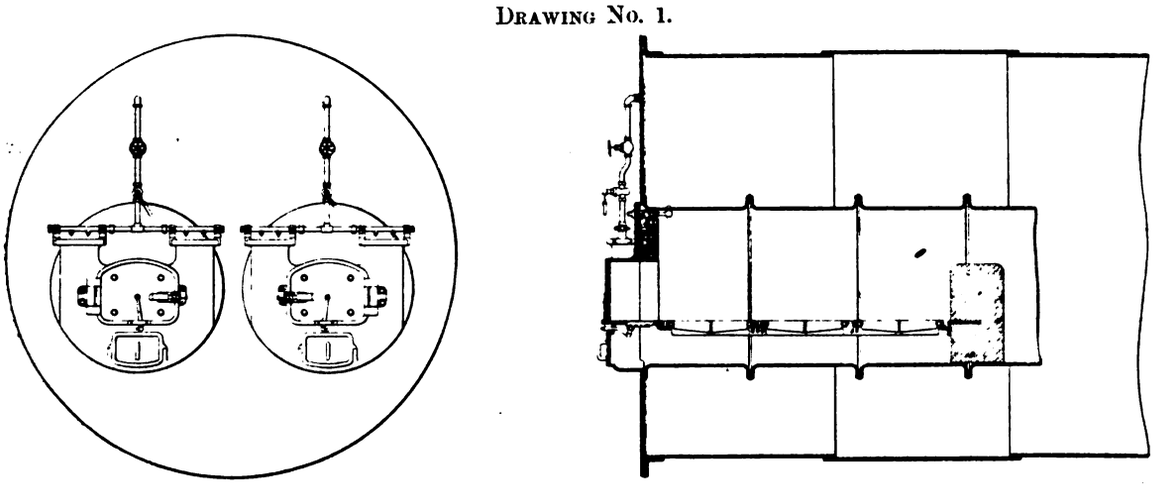
15293. Is it difficult to light?—It is rather difficult to light; it requires a great deal of wood, but once it is alight it is very good fuel indeed.

15294. You do not have to put paraffin on it?—Oh, no.

15295. What is the coal you were speaking about in Spain?—It is a kind of semi-anthracite fuel, a fuel known as Asturias, mined in the Barcelona district.

I should like, if I may, to put in these two drawings of the latest methods employed by us for successfully dealing with such low grade fuels as cannot be burned by direct firing under steam boilers.

DRAWING No. 1.



MELDRUMS PATENT LOW-GRATE FURNACE
VERTICAL TYPE
AS APPLIED TO LANCASHIRE BOILERS

*On the 21st of January, 1904. Mr. Goodrich wrote as follows:—I am now in a position to reply fully to Questions 15289 and 15292:—

Results of tests with two samples of Irish Anthracite Coal from the Castle Comer Estate Company's Colliery, Kilkenny.

No. 1. Large lump from the Skihana Seam:

Calorific power = ...	14·1 lbs. or 13,621 B.T.U. per pound.
Fixed carbon ,, ...	92·34 per cent.
Volatile matter ,, ...	6·66 ,, ,,
Incombustible ,, ...	1·00 ,, ,,
	100·00 ,, ,,

No. 2. Several small lumps, apparently slack, but not from the same seam as the above:

Calorific power = ...	13·4 lbs. or 12,952 B.T.U. per pound.
Fixed carbon ,, ...	81·14 per cent.
Volatile matter ,, ...	15·50 ,, ,,
Incombustible ,, ...	3·36 ,, ,,
	100.00 ,, ,,

I may add that the above samples were all analysed at the end of last week.

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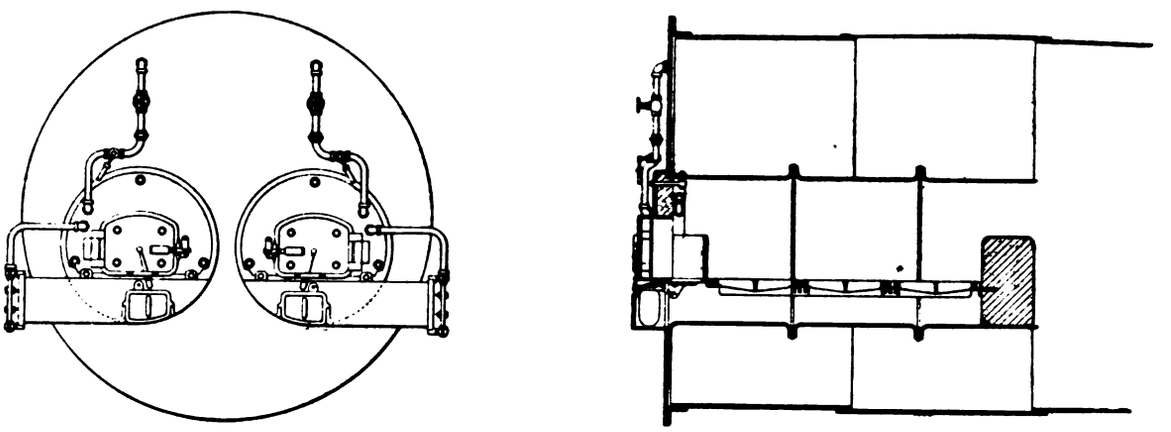
Mr. Walter Francis Goodrich.

16 June 1903.

DRAWING No. 2.



MELDRUMS' PATENT LOW-GRATE FURNACE, APPLIED TO A LANCASHIRE BOILER.

TWENTY-SIXTH DAY.

Wednesday, 17th June 1903.

PRESENT :

THE CHAIRMAN.

Sir GEORGE ARMYTAGE.	Mr. J. S. DIXON.
Sir WILLIAM LEWIS.	Dr. LE NEVE FOSTER.
Sir LINDSAY WOOD.	Professor HULL.
Mr. BELL.	Mr. MACLAY.
Mr. BRACE.	Mr. SOPWITH.
Mr. BRIGGS.	Mr. TEALL.
Professor DIXON.	Mr. YOUNG.

THE SECRETARY.
THE ASSISTANT SECRETARY.

Mr. FREDERICK PARKER RHODES, called ; and Examined.

Mr. Frederick Parker Rhodes.

17 June 1903.

15296. (*Chairman.*) You are connected with collieries, and you are Chairman of the Dalton Main Collieries, Ltd. ?—I am.

15297. Those are the Roundwood Collieries, near Rotherham ?—Yes ; we own the Roundwood Collieries, and we are also engaged sinking some expensive collieries to the deep at Dalton Main in the newer portion of the South Yorkshire coalfield.

15298. You are also connected with some large manufacturers of railway wagons, are you not ?—Yes. I am Chairman of Harrison and Camm, who are large manufacturers of railway wagons and wheels.

15299. Also I think you are Secretary to the South Yorkshire Coal Owners' Association ?—I am, and I manage their affairs generally.

15300. You are by profession a solicitor ?—I am, but all my life I have been actively engaged in or connected with the South Yorkshire coal trade, and my business as a solicitor is practically a mining business.

15301. The South Yorkshire coalfield is one of the principal coalfields in the country, is it not ?—It is ; and in my opinion it is the coalfield which contains the largest area of unworked and undeveloped coal.

15302. Do you speak of "area" there as referring to its extent in acres ?—I speak of it in both ways—both in acres and in proportion to the existing developed coalfield.

15303. Are the railway facilities in the field good ?—The railway facilities are good. We are amply served with railways, but our difficulty is that owing to our geographical position we are at a disadvantage as compared with other coalfields, because our lead to all our principal markets is longer.

15304. Would you just develop a little the point about the disadvantage compared with other fields ?—Yes ; for instance, if you take the export trade, our natural port for export is to be found on the Humber ; if you compare the distance there, say, with the average distance from the north of England collieries or from South Wales collieries, they are very much shorter than we are.

15305. That is to say, it is shorter to their ports ?—Yes, and, of course, obviously under those circumstances they get a much lower rate. Our distance to the ports would be over 50 miles.

15306. (*Mr. Young.*) Is that the average distance ?—Well, perhaps, 50 to 55 miles ; it is not easy to give an average figure at a guess when one is carrying distances in one's head. The same thing applies to the London market and to the southern markets. Of course, to reach those markets our coal has to pass through the Midland district and Derbyshire, which compete with us in exactly the same market.

15307. (*Chairman.*) Have you any competition by sea ?—Yes. the seaborne competition is very severe. Our coal competes naturally with the seaborne coal from the north of England and also with the seaborne coal from our neighbours in West Yorkshire ; they can reach London by the Aire and Calder Canal and the sea, and we have to compete with their coal, which is practically

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the same quality as ours so far as house coal and gas coal are concerned.

15308. Is there much coal going by sea from your district to London?—No, it is not a practical route.

15309 What is about the output of the South Yorkshire district?—There I have to give a guess figure, but in round figures it is about 16,000,000 tons.

15310. That is per annum?—Yes.

15311. I think you said that the field is being developed?—Yes; during the last four or five years the portion of the South Yorkshire coalfield lying to the south of the River Don has been taken up, and is being rapidly developed, and I think in the course of the next three or four years the existing output of the district will be increased by fully one-third. For instance, my company at the present time raise 250,000 tons per annum; in about two years from to-day we shall be raising 1,000,000 tons per annum, and in the course of another year or 18 months after that, that will be still further increased.

15312. What is the kind of coal?—The South Yorkshire coalfield produces steam coal, house coal, and gas coal, and all of them are of very good quality.

15313. Is there any sort of rough proportion or percentage that you could divide them into in those categories?—Speaking roughly, I should say the collieries working the Barnsley Bed, which produce the great proportion of steam coal, will draw about two-thirds of the total output, and of the quantity that they draw a portion again is represented by the soft portion of the seam; you may say, roughly, that the output of the steam coal collieries is 50 per cent. steam coal and the rest soft; that is not quite correct, but it is near enough for the present purpose.

15314. How do you divide the soft between house and gas coal—do you do so at all?—No, you cannot, because its destination depends really upon the state of the market. If there is a demand for house coal a considerable quantity of what would go for gas purposes goes for house purposes; on the other hand, if the house coal trade is slack, then there is a natural tendency to put it on to the gas coal market; it is available for either purpose.

15315. In what category would you put the coal which is used for factories?—Well, that is produced by all the pits, and it entirely depends as to the kind of factory and the kind of coal they want. A large proportion of our smaller coal goes into the West Yorkshire district for use in the factories and it is used in local works. But there has been a great change in recent years in the method of dealing with the smaller coal: we have had to put up expensive plants for screening it, washing it, and sorting it, and it is dealt with in a very different fashion to day to what it used to be 12 or 15 years ago.

15316. That is another way of saying that it is better prepared for the market, is it not?—Yes, much better.

15317. And therefore you get a much better price for it?—I do not know that we get a very much better price, but if we did not do it we could not sell the stuff under present conditions.

15318. But has not the tendency in recent years been to show rather a greater percentage of advance in what one may call the lower priced coals—I mean the small coal, the slack, and so on—than in the large coal?—If you speak of the last three or four years, that would be correct.

15319. There has been a general rise of price, has there not?—Yes, but it has been more in proportion in that class of fuel; and, personally, my opinion is that that was largely due to the increased demand for coke which has taken up a larger proportion of the small coal; and, as you know, if you take even a small quantity off a market that wants practically the whole quantity, it affects the price immediately.

15320. Could we get from you, roughly speaking, where the steam coal finds a market?—Yes; there are three great markets for the steam coal; first there is the market supplied by the railway companies, who require it for locomotive purposes. For that purpose it is equal to best Welsh.

15321. Do you mean ton for ton?—Ton for ton; its useful effect is as good as best Welsh, but it is not as good as best Welsh for steamship purposes, because it produces more smoke. Our next great market is the local demand of the ironworks and manufacturers in the vicinity.

15322. Does that include stationary boilers at factories?—Yes, to some extent. And our third market is the export market, and it is that market, of course, which has to take the surplus quantity which the home market cannot deal with.

15323. In speaking of South Yorkshire you spoke of the Barnsley Bed—you will excuse my ignorance of these things, but I only want to get it clear, if we can: do you treat South Yorkshire (leaving aside for the moment the description "Barnsley Bed") as including everything to the east of the field which has been worked in the Barnsley district?—Well, I have been asked on several occasions before Parliamentary Committees to define South Yorkshire, and I should define it by a line drawn from east to west, a little to the north of Monkton Main Colliery, and by another line drawn from east to west, somewhat to the south of Treeton Colliery.

15324. That is down Nottinghamshire way, is it not?—Well, it is just getting into Derbyshire and Notts. When you get north of the northern line near Monkton Main Colliery, you then come into that portion of the Yorkshire coalfield which is known as the West Yorkshire field; and the Barnsley seam there loses its character entirely, and becomes quite a different thing. As you go south of the line that I have indicated you approximate more and more to the Derbyshire Top Hard; you then get a coal which is hard—possibly harder than ours but which contains a greater percentage of ash, and begins to vary in character from the true Barnsley Bed.

15325. Then would you include everything east of the lines you have taken?—So far as the existing collieries are concerned, I should. What the underground developments in the future in that direction may reveal I cannot say. They may disclose an altered character of the seam again; but at present I should include everything.

15326. On the other hand, they may apparently extend as far as the Humber, and across it?—They may.

15327. You, in fact, treat all between the northern and southern points you have mentioned—all eastward of the existing workings—as being, at all events for present purposes, likely to be included in the South Yorkshire coalfield?—I do; the indications, so far as we possess them, point to that conclusion.

15328. Then you have told us that the natural ports of South Yorkshire are the Humber ports. Do you do any trade with Manchester or Liverpool?—Yes, we do; there is a certain trade which is being done with Manchester and Liverpool; that is done in part to the Manchester Ship Canal.

15329. Are you now speaking, when you mention the Manchester Ship Canal, of export coal in the sense that I should understand it, namely, coal not to be used by ships for bunker purposes, and so on, but which they are taking as cargo for export?—It would be both: when I speak of export coal it is not easy at the present moment, without a good deal of inquiry, to distinguish between bunker coal and coal for sale, so that it would be better to say that it includes both. Then in addition to that we send some direct to the docks at Liverpool,

15330. Again, possibly, for both purposes?—Yes, but mainly for bunkering there, I think. We also send a considerable quantity to Widnes.

15331. Is that for local consumption?—No, it is sent to Widnes because the rates are more advantageous; it is put into barges at Widnes and barged into the docks at Liverpool, and dealt with there, as one of your previous witnesses, Mr. Barrett, has described to you. I think there is no doubt that trade could be increased to a considerable extent if we were able to get there for less money.

15332. In point of distance, how does it compare?—There is not very much in point of distance. I have not got the exact distance; it is a little further than it is to the eastern ports on the Humber.

15333. (*Mr. Briggs.*) Not to Manchester?—No.

15334. Manchester is much nearer?—Yes, I was speaking of Liverpool.

15335. (*Chairman.*) Is Manchester nearer than Goole?—No, nearer than Hull.

15336. At Hull there are two dock systems, are there

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Mr. Frederick Parker Rhodes.

17 June 1903.

not?—Yes; there is the Alexandra Dock, belonging to the Hull and Barnsley Company, and the old docks, which belong to the North-Eastern Company. The Alexandra Dock is a modern dock, and well fitted with modern appliances. The old docks undoubtedly require very substantial improvement; they either want altering, or else a new dock is wanted to deal with the modern requirements.

15337. There is some scheme on hand, is there not?—I think the North Eastern Railway Company are fully alive to that position, and I believe they have done their best to get the necessary powers and to carry out a scheme to remedy it. But unfortunately at Hull you have conflicting interests, and I think a good deal of local jealousy. Whenever anything has to be done you have the North-Eastern Company to consider, and you have the Hull Corporation to consider, and you have the Humber Conservancy to consider, and it is a difficult matter to get all those parties to think alike.

15338. (*Sir George Armytage.*) Especially in Hull?—Especially in Hull. I think I indicated that I thought there were local jealousies.

15339. (*Chairman.*) When you speak of there being two distinct dock systems at Hull, and in view of what you have said about the Hull and Barnsley and the North-Eastern, you do not mean that they are distinct in this sense, that they are each of them only used by the one company?—Well, yes, that is so, practically, because the Hull and Barnsley Company own the Alexandra Dock. If you want to send coal to the Alexandra Dock it goes viâ the Hull and Barnsley.

15340. Does that mean that you cannot send coal by the North-Eastern to Hull, to the Alexandra Dock?—No, there is no practical physical connection to get to the Alexandra Dock; and the coal for the old docks goes by the North-Eastern.

15341. Do the Hull and Barnsley take no coal into the old dock?—No.

15342. Therefore they are two distinct systems in the sense that you speak of?—They are two distinct systems. Under the scheme that was projected some time ago it was proposed, when a new dock was built, that it should be built on terms arranged jointly between the North-Eastern and the Hull and Barnsley, and that both companies should have access to it. At present that scheme is in the air, and I do not quite know how it stands. I do not think there is anything actually done yet in the way of starting it.

15343. Are the shipping appliances good at Hull?—The Alexandra Dock appliances are good, but in my opinion the time will very soon arrive when the Alexandra appliances will be taxed to their utmost capacity. The appliances of the old docks were good in past days; they are not good to-day; they want remodelling, and the docks either want deepening, so as to take vessels of larger draught, or else you want a new dock that will do it; they are not up-to-date.

15344. We hear a great deal about large wagons in these days. Are the shipping facilities at the Alexandra Dock (which facilities you describe as good) capable of dealing with 20 or 30-ton wagons?—So far as my experience goes I do not think they are, and I think if you are going to deal with large wagons—that is in the sense of any material enlargement of the wagon—that you would have to provide appliances which would be capable of dealing both with the new large wagon and with the ordinary standard wagon of to-day. Since I prepared the proof which is before you I have gone rather further into that question of large wagons, and I may be able to give you some further information on the subject.

15345. Do you send any coal to Grimsby?—Yes, a considerable quantity.

15346. Is that an increasing port for the shipment of coal?—It is; and the dock accommodation requires to be increased. The Great Central Company in the present Session are taking powers for the construction of a new modern dock at Immingham, near Grimsby. That is a spot near Grimsby, where there is deep water at all states of the tide, and they are going there for that reason, I believe.

15347. Is the water as deep there as at Hull?—It is deeper, I think.

15348. Then with regard to the rates to the ports, how do they compare? Are they uniform, or to what extent do they differ?—We have no group rate in South Yorkshire as they have in Lancashire for Garston. The geographical position of each colliery is taken into account in fixing the rate. The highest rate that has existed in my time was a rate of 3s. 6d., and that rate has gradually been altered until the corresponding rate to-day would be about 2s. 6d. or 2s. 7d. It is not easy to give you an accurate average figure, because I have to guess in my head at the quantities that go and the rate from the nearest colliery and that from the furthest colliery; but I think about 2s. 6d. or 2s. 7d. would be a fair figure—say 2s. 6d.

15349. What would be the lowest rate, if that is the highest?—The lowest rate would be the rate from Denaby colliery; their rate is 2s. 5d., but it is reducible by an arrangement between themselves and the Hull and Barnsley Company in proportion to the quantity sent.

15350. (*Sir George Armytage.*) That is to Hull?—That is to Hull. I am speaking of the Hull rate; when the quantity reaches a given figure the rate drops, and their lowest rate, if I remember rightly, would be 2s. 3d.

15351. From Denaby to Hull?—From Denaby and Cadeby to Hull.

15352. What is the quantity upon which that is paid?—On the largest quantity that they can send under their agreement.

15353. But what is the limit of the quantity?—I cannot give you the exact figures, but I know that it is the fact—that as the quantity rises the rate drops.

15354. The quantity is something like 100,000 tons, I suppose?—Larger than that.

15355. (*Chairman.*) You have given us, as far as you know, the highest and the lowest rate, and you have spoken of Hull?—I am speaking of Hull.

15356. How does the Goole rate compare with Hull?—The Goole rate is a little lower than the rate to Hull. Our average rate to Goole is about 2s.

15357. Yes, and Grimsby?—Grimsby compares with Hull.

15358. You mean that it is uniform with Hull?—About the same as Hull. Of course if you had any marked difference between the two ports you would influence the trade from one to the other.

15359. Then are there any dock dues?—Yes, 2d. is the figure that is taken to cover the cost of dealing with the coal at the docks, including dues. Then you have to add the wagon hire, which you might take at 6d. or 7d.—say 6d.

15360. Or provide your own wagon?—Yes, it comes to the same thing; if you provide your own wagon you charge for it.

15361. Quite so?—And as a matter of fact, the great bulk of our trade is done in our own wagons. So that would give you the total cost of putting coal on board at Hull at, say, 2s. 6d. rate, 2d. docks, plus 6d. wagon, or a total of about 3s. 2d.

15362. (*Sir William Lewis.*) Does that include weighing?—That includes everything.

15363. (*Sir George Armytage.*) When you say that the cost of the wagon may be taken at 6d. or 7d., do you mean 6d. or 7d. per ton?—Yes, per ton.

15364. *Chairman.*) Having regard to the distance, do you consider this rate is excessive?—No, I cannot say it is, because you see if you take the distance at about 50 miles, and if you take that rate which I have given you, it does not work out to a figure very much higher than ½d. per ton; it is a little higher. If it were 60 miles it would be exactly ½d. The railway companies are under a disadvantage with regard to that rate. We have not got one company which goes straight to the port. In the case of a number of our collieries we have to hand the traffic over to one company, and it passes over their system to reach the lines of the two shipping companies.

15365. It requires an amalgamation of the companies running there, I suppose; that would do it, would it not?—No, I do not agree with that, if you mean an amalgamation of the Hull and Barnsley and the North-Eastern.

15366. (*Sir George Armytage.*) You want facilities for taking it on the most direct route from the colliery to the port, whosoever line it goes over?—No; what I mean is this, that I cannot say that the companies

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deal with us unfairly so far as the Hull rate is concerned; and in making that remark I point to the fact that for a number of the collieries it has to go over two separate systems in order to reach the port, which makes it more difficult for the companies. It would be a great advantage to us if we could get that rate reduced to Hull.

15367. (*Chairman.*) In other words, that one company travelling over another company's road or giving facilities, makes a charge for it, I suppose?—Yes, necessarily—you have two people to take into account instead of one. I should very much like to see the rate still further reduced, and in my humble opinion it would pay the companies to make some further reduction, but I cannot say that the amount we are charged is an excessive figure, having regard to the distance of the lead.

15368. (*Mr. Bell.*) Do you know the percentage of coal that is sent to export from South Yorkshire?—I can give it to you, but I have not the figure in my head. I kept away from all those matters, because I thought they would have to be gone into probably on some future occasion, and I confined myself to-day simply to this question of transit, which I thought was all I was desired to deal with on this occasion.

15369. (*Chairman.*) Have you considered the question of larger wagons?—I have, and I have had the opportunity of seeing what was said by Mr. Shaw and by Sir Alfred Hickman on the subject.

15370. May I just ask this question: have you ever been in America?—No, I have not, my Lord.

15371. Therefore, you are not personally acquainted with the methods of dealing with this traffic there?—I am not, but I have discussed it, and I have heard it discussed until I almost begin to think that I have been there.

15372. Now, will you tell us what you think about larger wagons?—I think the question of larger wagons has to be looked at from two points of view, the traders' point of view and the railway companies' point of view.

15373. Will you just define "traders" in that sense? Are you not a trader when you send coal for export?—By "trader," I mean a trader in the sense that we are traders in South Yorkshire, and our trade is carried on practically in our own wagons. Now, looking at it from the point of view of the trader owning his own wagons, you have to take into account——

15374. Or the colliery owner owning his own wagons?—By "trader," I mean for to-day, colliery owner—you have to consider what advantage it is to him to use larger wagons; and unless you can show an advantage, naturally he will not use the larger wagons, but will continue to use his existing stock, and to replace it by similar stock, because his whole colliery is laid out to meet the conditions that exist while he is using his existing stock. If you are going to increase the height of his wagon, or if you are going to materially increase the length of his wagon, or very materially increase the length of the wheel base, all those conditions involve alterations at his pit and consequent expenditure on his part which, in some cases, might be very serious, and which, in many cases, might be difficult. For instance, if you are going to increase the height of the wagon to any material extent, that means increasing the height of the point at which he has screens delivering into the wagon; that, in many cases, would be an extremely serious, and, in some cases, a very difficult matter, because it must not be forgotten that in the case of the older collieries those appliances were originally designed to meet a still lower wagon than the standard wagon which is in use; and though it is easy to alter a screen, you must bear in mind that the screen has to be in proportion to the height of the pit-hill, and to the height of the wagon into which the coal drops. If you tilt up the screen so as to flatten it beyond a certain point, then your coal does not travel over the screen as it should do. If you shorten the screen so as to avoid tilting up, you do not get the full benefit of the screen. On the other hand, if you have to heighten your screen without doing either of those things, it means that you have got to increase the height of your pit hill; and, therefore, it is by no means a simple matter to deal with. In my opinion, from the point of view of the trader owning wagons, where his screens can be made to take them, and where the conditions at his colliery allow of their use, the cheapest wagon for him in the future is a 15-ton wood wagon. That is my opinion; that is from the point of view of the colliery owner. A 15-ton wagon would give him the largest increased carrying capacity per wagon in return for the smallest increase of cost. But the wagon that would suit the private trader best (which, in my opinion, is the 15-ton wagon), would not suit the railway company equally well, because the railway company, if they go in for a large wagon, would want to save the weight of the tare as compared with the carrying load; and from their point of view, if you are going in for a saving of that kind which is going to give a considerably increased economy in hauling the load, then you have to go in for a very much bigger type of wagon—a 30-ton, or, possibly, 40-ton wagon. But the moment you go in for that wagon, you are going in for a wagon which, in my opinion, is not suited for the requirements of the ordinary trader.

15375. (*Sir George Armytage.*) For present requirements?—For present requirements; and where the cost of the alterations is too great. If you were constructing wagon stock to-day for an entirely new ideal coalfield, starting one to-day with ports to deal with its coal, and with everything constructed for a special trade of that description, of course the very big wagon would be the cheapest; but even then if you are going to deal with the general trade of the country, I do not think that is the case, because the colliery owner cannot do with a 40-ton wagon lying idle in his sidings; he cannot use a 40-ton wagon for supplying a 10-ton order, and, in my opinion, therefore, the 15-ton wagon is the one which would give the best return to the trader.

15376. (*Chairman.*) And one, I gather, which you think would come within the length of wheel base and the height of the wagon, without serious alteration of the existing appliances?—Yes; it is the nearest to it, my Lord. You see, if you take the standard specification for a 15-ton wagon——

15377. What wheel base are you reckoning?—I will give it to you: you have in a 10-ton wagon a 9ft. wheel base; in a 15-ton wagon you have 9ft. 9in. Now, the length over the buffers in a 10-ton wagon would be 18ft.; in a 15-ton wagon it would be 21ft. The 15-ton wagon carries half as much more as the 10-ton wagon; but when you come to deal with cost, the cost of the 15-ton wagon is only something like £12 more than the existing 10-ton wagon; and therefore for an increase of about 12 per cent. in cost you would get an increase of 50 per cent. in carrying capacity.

15378. (*Mr. Briggs.*) It is not 12 per cent., is it? It is about 20 per cent.?—Yes, my figure is wrong. I said "per cent." instead of "pounds." You take the price of the existing 10-ton wagon at something like £62, and the price of your 15-ton wagon would be £72 or £73. Now the difference in price there is small as compared with the increase in the carrying capacity of the wagon; therefore, if you are going to build new stock, and if your colliery is capable of taking it, and the docks and railways can deal with it, that is the wagon which, from my point of view, would give the best return to the private trader who has to buy and use his own wagons.

15379. (*Chairman.*) In fact, you are going to increase the cost of the wagon by one-sixth, and its capacity by 50 per cent.?—Yes.

15380. (*Mr. J. S. Dixon.*) What are the respective weights—the tares?—The tare in a 10-ton wagon would be about 6 tons 2 cwt., the tare in a 15-ton wagon would be about 7 tons 6 cwt.

15381. (*Chairman.*) Therefore the weight is in proportion to the increase of cost?—Yes.

15382. (*Sir William Lewis.*) The increased weight is only 24 cwt. to carry 5 tons more?—The moment you get beyond the 15-ton wagon, and you get up to the 20-ton wagon, you have an entirely different state of things; you there must have either a steel frame, or else you must have a composite frame, such as some that are in use on the North-Eastern, of steel and wood. I am not prepared to say myself how those will turn out until I know more about them. But in any event the increase in height then becomes a serious matter, and your cost immediately is very considerably increased; with a steel frame you have a cost then of something like £110 to gain that extra 5 tons, as compared with the difference between the 10-ton wagon and the 15-ton wagon. There is another disadvantage: directly you get into steel you are at a disadvantage with regard to the repairs; if you have a wood wagon it is easily repaired, and it can be repaired in many cases at your local repairing stations scattered all about

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Mr. Frederick Parker Rhodes.

17 June 1903.

the country; but if you have a steel wagon and anything goes wrong, it has to go right away to where it was made, or to some other place fitted with similar appliances, for the purpose of being dealt with. There is another objection to the steel wagon, in my opinion, which I think time will reveal to a greater extent than it has at present, and that is the difficulty of preventing corrosion. As long as wood stands sound it is good, and when the time comes you can replace it without very much difficulty; but in the case of the steel wagon, you never can tell what damage corrosion is doing at those parts of it which you cannot conveniently get at.

15383. (*Sir George Armytage.*) Are you speaking of steel bodies or steel frames only?—Steel frames. Then directly you get to the 30-ton or 40-ton wagon, if you take the 30-ton wagon for instance, there you must have bogies, and as soon as you get to that you have an enormous increase in cost. Your cost for a 30-ton wagon with bogies to-day would be over £250; if you compare that with the 15-ton wagon you will see the difference from the point of view of the trader who builds and owns his own wagons; he gets a 15-ton wagon which would involve the least alteration in his colliery for the expenditure of something over £70; he gets a 30-ton wagon for the expenditure of something over £250. The gain to the Railway Company is, of course, greater in the bigger wagon; but, on the other hand, the trader would have to make far more serious alterations to enable him to deal with it at his pit.

15384. (*Chairman.*) You speak of a 15-ton wagon, and we are talking about coal; do you speak of a 15-ton wagon as a wagon which is capable of bearing the weight of a load of 15 tons, or are you speaking of a wagon the size and capacity of which would hold 15 tons of coal?—I am speaking of the wagon built according to the present specifications, and capable of carrying with safety 15 tons of coal.

15385. By "capable of carrying," you mean to say as regards capacity—capable of holding?—Oh, no, more than that—up to standard requirements, and capable of carrying with perfect safety, and so as to meet the requirements of the railway companies.

15386. I agree that "carrying with perfect safety" means that the springs and everything else connected with the wagon are strong enough and capable of carrying that weight; but my question is, are the dimensions which you have given us dimensions which, as regards the carrying capacity, are capable of holding, and large enough to hold, 15 tons of coal?—Yes.

15387. (*Sir William Lewis.*) The contents?—Yes. I will give you the cubical contents as I have them worked out here. The cubical capacity of the ordinary 10-ton wagon is 404 cubic ft., the cubical capacity of the 15-ton wagon is a little under 600 cubic ft.

15388. (*Mr. Bell.*) Is that streak measure?—Yes.

15389. (*Chairman.*) That is practically adding 50 per cent.?—Yes.

15390. Will you tell us the length and the height?—The outside length of the 10-ton wagon over buffers is 18ft.; of the 15-ton wagon, 21ft.; the width is the same in each—8ft. 3in. It goes without saying that you cannot alter that width, or only very slightly.

15391. Is that the outside measurement?—Yes, these are all outside measurements; the height over all in the 10-ton wagon is 8ft. 1½in.

15392. (*Sir William Lewis.*) That is off the rail?—Yes, and in the 15-ton wagon it is 8ft. 6½in. The tare in the 10-ton wagon is 6 tons 2 cwt.; in the 15-ton wagon, 7 tons 6 cwt. The wheel base in the 10-ton wagon is 9ft.; in the 15-ton wagon, 9ft. 9in. Those are both wood wagons. If you wish it, I can give you the same figures for the 20-ton wagon; but I think the 20-ton wagon really is out of the question.

15393. Will you please put in a table so as to get it all on the notes?—With pleasure.

TABLE A.

SHOWS Dimensions and Comparative Figures of Wagons carrying from 10 to 20 Tons of Coal, and built in accordance with general Specifications.

	10 Tons.	12 Tons.	15 Tons.	20 Tons.
	Ft. Ins.	Ft. Ins.	Ft. Ins.	Ft. Ins.
Length over buffers	18 0	18 0	21 0	24 6
„ inside	14 6	14 7	17 7	21 1
Width outside	8 3	8 3	8 3	8 3
„ inside	7 0	7 6	7 6	7 6
Height over all	8 1½	8 8¾	8 6½	9 2⅝
„ inside	4 0	4 7¼	4 5	5 2
Wheel base	9 0	9 0	9 9	12 0
	Tons. Cwts.	Tons. Cwts.	Tons. Cwts.	Tons. Cwts.
Paying load	10 0	12 0	15 0	20 0
Gross load	16 2	18 12	22 6	28 12
Tare	6 2	6 12	7 6	8 12
Paying load per cent. of gross load	62·1	64·5	67·2	69·9
Tare per cent. of paying load	61·	55·	48·6	43·0
Tare per cent of gross load	37·8	35·4	32·7	30·0
	Cubic Feet.	Cubic Feet.	Cubic Feet.	Cubic Feet.
Cubical capacity	404	503	582	817
Frames	Wood or steel.	Wood or steel.	Wood or steel.	Steel or wood and steel.

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15394-7. (*Sir George Armytage.*) Shortly, we may take it that a ton of coal takes 40 cubic ft.;—Yes, roughly. I may say that I read with some interest what Mr. Shaw said with reference to altering the existing 10-ton wagon into a wagon capable of carrying 12 tons. I do not see myself why that should not be done if the railway companies were willing to pass and accept a wagon so altered; but I do not see how you could do what Mr. Shaw suggested, namely, increase the journal; you must either alter your wagon, using the existing wheels and axles or if you do not do that you must put new axles in.

15398. (*Chairman.*) Do you agree with Mr. Shaw, who gave evidence upon the question of the dependence of the colliery companies upon the railway companies for the supply of wagons?—I am strongly of his opinion there. We in South Yorkshire have always carried on our trade in wagons provided by ourselves or by our customers who send for the coal, subject, of course, to this, that the coal which is taken by the railway companies is sent for in their own wagons; for that purpose they are customers who send in their own wagons. It may be prejudice, but, personally, I have a very strong view that I should not like to be, and I would not be, dependent for the supply of wagons upon a railway company, or any outside source, which had to serve me and a number of other people; I would provide sufficient wagons to deal with my own output.

15399. Theoretically, it is the right plan and the more economical plan, is it not?—Which, my Lord?

15400. One reservoir from which to draw?—Well, that depends upon the point of view from which you look at it. If you are trying to find out a method by which you can supply the whole trade of the country with wagons to carry that trade——

15401. When the man wants them?—Yes, when he wants them—then theoretically if the person who wants wagons gets what he wants at the time that he wants them from the person who has to give them, obviously one huge pool or reservoir ought to do it cheaper; but it is a serious matter for a colliery owner if he does not get what he wants when he wants it, and I myself would prefer to suffer some inconvenience in the way of extra capital and some increased cost, in order to be perfectly certain that I was master in my own house, and that I controlled the supply of wagons which were necessary for my own trade.

15402. Yes, that I understand, but would you not say, as a matter of theoretical organisation at all events, that 50 collieries in a district, each of them on the average using 100 wagons, would be more likely to get their 100 wagons with certainty if they took them out of 50,000 wagons in one hand, rather than having to keep the margin of safety?—Well, as a purely academical and theoretical proposition I would say yes, but in practical working I should say no.

15403. You get your wagons back, in fact, as quickly as you want them?—No. We never get all we want in this world, and I do not think we get them now quite as quickly as we used to do, but I think we get them back quite as quickly as we should if we had to depend upon one concern to hand them to us.

15404. But it does involve a good deal of extra work for somebody, does it not, and therefore some extra cost, to have to take every wagon back to its particular destination?—I do not think there is really so much in that; take, for instance, our coal going to Hull; as a matter of fact, the bulk of it goes in train loads; those wagons have to be distributed over a district, say, 10 or 12 miles in length, and I do not think it really would make very much difference whether they went to one colliery or to the other in point of convenience, because the engine which takes the empties back as a rule brings a full load away.

15405. Does that also apply to coal sent to London?—It would not to the same extent, but I do not think it makes so much difference there. For instance, coal going by the Great Northern to London would go down to Hexthorpe, and it gets marshalled there and sent off to London; the wagons come back in the same way, and they are divided there and sent to the different collieries, and I do not think it makes very much difference.

15406. (*Sir George Armytage.*) Then you do not think from your point of view that it would be practical to have a great wagon trust, so that all the railway companies and all the colliery owners should put all their wagons together into one trust; you think it would not work, and that the individual colliery proprietors would not like it?—I should not like to be dependent upon it. I prefer the ills that I have.

15407. You really are of the same opinion as Mr. Shaw in that respect?—I am, and I may say that that opinion is shared by all the other coalowners in my district.

15408. (*Chairman.*) You are speaking, as I understand, not as against what I will call putting into one trust the whole of the wagons belonging to the whole of the railway companies, but you want to keep your own independently and separately?—I do.

15409. (*Sir George Armytage.*) As regards the earlier part of your evidence, where you spoke of the South Yorkshire coalfield, I do not think you told us exactly what proportion of that large quantity was exported?—No.

15410. Could you get us that information?—I will try to do so.

15411. You also spoke about the proportions of the steam, house and gas coal, and I think you got as far as to say that about two-thirds was steam coal?—Yes.

15412. Some 16 per cent. of it was soft. Was not that so?—I will state the figures again, so as to make it perfectly plain. About two-thirds of our collieries work the Barnsley bed; about one-third work other seams; these other seams mainly produce house and gas coal; they do produce a small proportion of second class steam coal. The two-thirds working the Barnsley Bed, out of the total quantity they raise, produce about half hard steam coal and the remainder other qualities.

15413. (*Chairman.*) It is a little complicated; the 66 per cent. you divide practically into 50 per cent. of steam and 50 per cent. of soft; and as regards the 33 per cent., do you alter the proportions?—Really I could not give you anything but a mere guess as to that 33 per cent. There is a seam we have, called the Parkgate Seam, and that seam is coming more into work as the older pits are abandoning the Barnsley bed. That seam contains what is a very fair second-class steam coal. Therefore a proportion of the one-third of the output is second-class steam coal; but if I attempted to-day to give you the exact proportion it would only be the merest guess.

15414. (*Sir George Armytage.*) In speaking of the ports for your coal, you laid great stress upon, and seemed to speak more particularly of, Hull?—Yes, the Humber ports; I took Hull as an instance.

15415. Yes, and the rates quoted were practically in reference to Hull, were they not?—Yes.

15416. How does your Manchester rate compare with that?—I put in a little table showing approximate average distances and rates from South Yorkshire Collieries to different ports.

TABLE B.

Port.	Approximate average, distance in miles.	Rate per ton.	Amount per ton per mile.
		s. *d.*	*d.*
Hull - - - - -	50	2 6	·600
Goole - - - -	26	2 –	·923
Grimsby - - - -	60	2 6	·500
Partington (Manchester Ship Canal).	48	2 8	·666
Liverpool - - - -	75	3 2	·506

15417-8. Have you sent any large quantity to Goole? Not very much.

15419. How is that?—The Goole rate, to put it in plain English, is not sufficiently low as compared with the other rates.

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Mr. Frederick Parker Rhodes.

17 June 1903.

15420. Does that mean that you prefer to send it to Hull at a higher price?—No, I would not say that; I would say that it pays best, as a rule, to send it to Hull at the existing difference between the two rates.

15421. Are the shipping appliances at Goole satisfactory?—I should not like to say that they are not.

15422. I mean they are not the same as you were describing at Hull?—No.

15423. You think that in the near future there will be nearly one-third added to the output of this South Yorkshire coalfield?—I am quite sure of that; and the bulk of that will have to go for export.

15424. (*Chairman.*) May I ask this one question upon that; it is a little important: the statement that in a very short period of time we may look forward to the output of the South Yorkshire coalfield being increased by one-third runs into very large figures? Do you keep in mind, in making that statement, the possibility of some portion of the present field which is now worked being worked to a less extent?—Yes, I have that in my mind, but this is what happens. Where an old Barnsley bed colliery ceases to exist as such, and is worn out, the owner does not pull up his engines and destroy his plant, but having his plant there, and having his pits, he puts them down to one of the other seams lying below, which he would not work while he had the Barnsley bed to go at, and he creates a colliery in those newer seams, and does the best he can with that. You see he is in this position, and that he can work a seam with a colliery where his plant and everything is ready to his hand, where he would not attempt to work it if he had to sink the pits and to provide the plant to do it. All that he has to do is to deepen his shafts to a certain extent, and all his expenditure is there; and if he is a prudent man, of course he has already written off the cost of his concern out of his Barnsley bed.

15425. Then we may take it that your answer means literally what it says, that *qud* output calculated by tonnage, if we may do so, you anticipate that the output will be increased by one-third?—I do.

15426. (*Sir George Armytage.*) But not simply from those deeper workings; a great deal of this will come from new pits which are being sunk at greater depths more to the east?—Yes, and to the south. The bulk of it will come from the new collieries, and the exhaustion of the old Barnsley bed collieries will not affect it, because their output of Barnsley coal will be replaced by output of Parkgate or some other seam.

15427. Therefore you do not think that there will be very much reduction of output upon the present portion of the field, which is now full of coal pits?—No, I do not.

15428. Because they are simply working deeper seams?—Yes, that is it; there will be a greater reduction in the output of steam coal from those older collieries, but not of the total coal, not for a long time to come.

15429. You say that the cost of a wagon may be taken at between 6d. and 7d. per ton; that would be as between the coalfield and Hull?—Yes.

15430. That would leave a very good profit, would it not?—No, it would not; it leaves just about a fair profit. I do not think that the charge which the railway companies make for the use of the wagons is an excessive figure, and that is the figure which in practice we charge ourselves with in our own books.

15431. But if you put that price on a 10-ton wagon, and as you show us that a 15-ton wagon costs very little more in proportion, the proportionate rate for a 15-ton wagon would be rather high, would it not?—No, that is where I say the great inducement would be to the trader to adopt the 15-ton wagon.

15432. And that would be an advantage to the trader?—Certainly; and you will not get the trader to make any alteration in his existing stock unless you give him an advantage. If you want him to use the 30-ton or the 40-ton wagon you must give him an advantage in rate, or something of that sort, to induce him to go in for them. If you leave him to his own devices he will go for the wagon that will pay him best, and in my opinion that is the 15-ton wagon.

15433. I see what you mean now. If you have a 15-ton wagon you get a very much larger capacity with a very much smaller cost, and you get as much per ton for the cost of the wagon, whereas if you have a 30-ton wagon it would cost you a great deal more money, and you would not in proportion get so much profit out of it?—Yes. It does not matter so much what you do, whether you charge it in your wagon hire or in the price of your coal, but as a matter of fact you could afford to run your 15-ton wagon at a less cost per ton than your 10-ton wagon.

15434. You say that if the cost of putting coal on board at the ports could be reduced it would be a great benefit to the trade. Is the cost of putting coal on board at the ports now excessive?—I have said already that by "cost of putting coal on board," I mean the total cost, including rate, wagon and everything; and the greater part of that is made up of railway rate; and I have already said that, although I should like to see that reduced, and I believe it would be to the advantage of the companies to make some further reduction, I cannot say, and I will not say that it is an excessive figure.

15435. Have you had any experience of steel-framed wagons?—Yes, we build a good many.

15436. Have you found in practice that there is difficulty in repairing them?—I will tell you what I found in practice. We put up a shop experimentally, for the purpose of building steel-framed wagons when they first came into use, and our idea was that as time went on we would increase the capacity of that shop as the demand increased. Now I have never found any necessity to do that; the shop that we put up at the beginning is quite capable of meeting the demand that we have to supply for steel-framed wagons, and in my opinion that points to the fact that the general trader, as a rule, is not enamoured of those wagons.

15437. (*Mr. Briggs.*) You speak of a steel underframe?—Yes.

15438. Not a steel body?—No.

15439. (*Chairman.*) But you would put it a little stronger if you spoke of those?—Personally, I should not go in for a steel wagon myself if I were ordering one. I do not see any advantage in them, and I see disadvantages; but then other people may not have the same views.

15440. What will you do when wood is not available?—Well, my Lord, there will be someone else dealing with those matters then, and I will leave them to solve the difficulty.

15441. (*Sir George Armytage.*) Have you no colliery anywhere at which you get any advantage by train loads?—No. I think it was a great mistake myself, from the coalowners' point of view, when the Board of Trade proposal for a train load rate was finally rejected by the Duke of Richmond's Committee. I wish it had been adopted; I believe it would be to the advantage of the coalowners, and I believe it would be to the advantage of the railway company. I believe that a very considerable part of our trade could be carried on by means of trade load consignments, and if there was an inducement to the colliery owner to do it, it would be to his interest to try to arrange his traffic in that way, and obviously it would be very much to the advantage of the railway company if that could be done. But as long as he gets no advantage from the train load rate he will not go out of his way to make up his traffic in train loads.

15442. Then you have not had any arrangement of that sort?—No. I may say there were some arrangements of that kind which existed some years ago, but they were put an end to. There was a very important trade from South Yorkshire to London in gas coal, and that trade was built up, and carried on at a special rate, which was lower than the ordinary rate, the coal all being sent in train loads. The railway companies for some reasons of their own destroyed that rate soon after the present Act came into operation, and they destroyed our trade with it. Newton Chambers alone at that time sent nearly one-fourth of their output to the Gas Light and Coke Company, and that trade was all destroyed. I tried to get the railway companies to continue the reduced rate, and I found it impossible. I offered to bring a friendly action, if there was any question as to the legality, and settle it in that way. I asked them to put the rate in the rate books, and publish it, or deal with it in that way, because it was not a secret rebate—everybody knew about it, but I could not get any further, and the rates were put an end to, and our trade went.

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15443. (*Dr. Le Neve Foster.*) How deep are these new sinkings, which you are speaking of?—Our collieries will be a little under 700 yards to the Barnsley seam; the others will vary from, say 650 yards up to 800 yards, or a little over.

15444. And how far are they from existing collieries?—A considerable distance, because you see with a modern colliery you are obliged to have such a much larger acreage than you had with the old colliery; for instance, my company have either leased or locked in about 10,000 acres of coal, and I do not think that it is any too much. Well, if you had been creating a colliery 15 years ago, you would have said that one-fifth of that quantity was a very nice coalfield; therefore, you see, dealing with it on those lines, 30,000 or 40,000 acres, which represents a very large area, does not fit up a very large number of collieries, and, therefore, they are further apart, and further away from the old pits than they used to be.

15445. How much further east, do you think, you will be able to go?—That is a matter I should like to deal with, if you will allow me, at another stage of the inquiry, if it becomes necessary; I should not like to give a hasty answer on that point.

15446. (*Mr. J. S. Dixon.*) You have pointed out that a 10-ton wagon weighs 6 tons 2cwt., and a 15-ton wagon 7 tons 6cwt. I should like to bring out this: that in the first case you carry one ton of coal for every 12·2 cwt. of the weight of the wagon, and in the second place you carry an extra 5 tons for every 4·8 cwt.?—If you have worked out those figures, I will take them as correct.

15447. So that that shows a very great advantage in the 15-ton wagon?—The percentage of the tare to the paying load would be, in the case of the 10-ton wagon, 61 per cent., and in the case of the 15-ton wagon, 48·6 per cent.

15448. Yes, that comes to the same thing?—Yes.

15449. Then with regard to the question of the railway companies owning the whole of the wagons, would there not be some advantage in return cargoes by the empty wagons?—That was the great argument which was used, if I remember rightly, when the Midland Company went in for the purchase of wagons, and as I say, it is one of those arguments which is perfect in theory, but which does not work out in practice. I have never yet myself seen a railway company's coal wagon going back with any load in it except pit props. There may be some, but I have never seen them; you see them in trains all over the country going back empty. Now, if that happens with railway companies' wagons to-day, it would happen with them in the future; and if any of you gentlemen travel on the Midland system, I think you will bear out my statement. I have never seen Midland coal wagons going back under load, except a very small percentage with pit props, or something of that sort.

(*Mr. Briggs.*) I suppose if there were to be a change to 15-ton wagons on a large scale, it would be necessary, in order to make any marked effect on the cost of carriage to the advantage of either the railway company or the consumer, in the first place, that all the shipping appliances at all the ports to which you send should be made to carry those wagons?—Yes; and I also lay down this proposition: that they could only be used with advantage by the coalowner whose place was so laid out as to permit of their use there.

15450. I am assuming that you would have to make it worth while to the coalowner to alter his place in those cases?—Yes.

15451. And to do that you must have all the shipping appliances made so that the wagon could be used from any port?—That is so.

15452. (*Chairman.*) But is it a fact that the alteration from 10 tons to 15 tons would involve any alteration in the shipping arrangements?—Yes, I think in some cases it undoubtedly would.

(*Chairman.*) There is no larger wheel base.

15453. (*Mr. Briggs.*) It depends upon the strength of the cranes and the weights. Do you not think that the 15-ton wagon would be too large a wagon for the average house coal traffic?—I should not like to work my traffic entirely with 15-ton wagons; that is the difficulty. I think myself that for the house coal traffic, for what one might almost call the retail part of our trade, an increase in the carrying capacity of a wagon often presents very considerable difficulty. You have a great number of small orders, which do not amount to much in themselves, but which form an important matter in the aggregate, where a man only wants 7, 8, or 9 tons, and where, therefore, if you have nothing but 15-ton wagons, you would have to run your 15-tonner with a half load. You would either have to do that, or you would have to have a certain proportion of 10-ton stock for dealing with that class of trade.

15454. Still, as a rule, the colliery would keep its old 10-ton stock for that, and it would be economical to change to 15-tonners if you were assured of the shipping appliances being able to take it?—Yes. Of course, in dealing with this question one must not forget this, that it is all very well to talk of adopting the 15-ton wagon, or any other type of wagon, but the power of production of the wagon works in the country at the present time is only equal to the demands of the country in the way of replacement of ordinary stock, and if you were to go in for the destruction of a considerable amount of stock, and the replacement of it by an entirely different type of stock, there would be a very serious problem to consider. I think that will make itself manifest in the replacement of the dead-buffer waggons which are going to be condemned; I doubt very much whether those can be replaced in the time that is contemplated.

15455. There is another question upon that: you mentioned the fact that your district does not do as much trade at Goole as at Hull. Is it not the fact that the greater part of your export is of hard steam coal, the markets for which are not those particularly supplied from Goole. You ship it in larger ships than can come up to Goole?—We send a very considerable proportion of gas coal and house coal as well.

15456. But the coal for the Baltic, for instance, is carried in larger vessels than could come up to Goole?—Yes, the bulk of the Baltic trade is.

15457. And you have the trade, I presume, to South Africa, Egypt, and South America?—Yes.

15458. All of which, I suppose, is carried in larger vessels?—Yes.

15459. You laid stress upon the new dock being one which would admit, if possible, larger ships?—That is so. To put it in plain English, assuming we could get to Goole cheaper we should be very awkward competitors with your district in regard to a portion of the trade which you do with other markets.

15460. Undoubtedly.—There is not very much difference between the two classes of coal from the two districts for the better house and the better gas coals.

15461. For certain purposes, but not for steam?—No. I say for house and gas coal purposes there is not much difference between them.

15462. (*Mr. Maclay.*) You said in the earlier part of your evidence that the railway companies used your steam coal to a great extent, and that the results were equal to the best Welsh coal?—Yes.

15463. Do you supply much of that coal for steamers' use?—Yes, we do. There is a very large quantity of it goes for bunkering purposes, and there again, as far as its useful effect is concerned, it is as good as Welsh. We make the people who use it rather dirtier than they do in Wales; we produce more smoke, and we cannot avoid that.

15464. You mean to say that ton for ton, apart from the question of smoke, the coal which you supply is equal to the best Welsh?—That is so. Upon that point I remember very well indeed discussing the matter once with Sir Henry Oakley, who told me he had made very careful experiments, and he had come to the conclusion that best South Yorkshire for locomotive purposes was, if anything, slightly better than Welsh; and I have no doubt the reason for that would be that, its calorific power being the same, mechanically it is a stronger coal.

15465. Do any of the large American liners use that class of coal?—Yes, I think so; the coal, for instance, which goes to Liverpool is to a large extent for bunkering purposes—some for export and some for bunkers.

15466. Do the Government ever take that class of coal for His Majesty's ships?—Most of the South Yorkshire collieries are on the Admiralty list; but sitting here and answering that question on the spur of the moment, I should not like to say for what purpose it is used. Undoubtedly, if you coaled a war-ship with

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Mr. Frederick Parker Rhodes.

17 June 1903.

South Yorkshire coal she would leave a very much bigger trail of smoke behind her than if she were burning best Welsh.

15467. But, apart from that, would the result be equal?—Yes, subject to this, that I think the best Welsh coal stows a bit better than ours, and I believe you can get a larger proportion into the same area when you are stowing Welsh coal than you can with the South Yorkshire.

15468. (*Mr. Brace.*) The specific gravity is a little more?—It is; that is what I have always understood.

15469. (*Mr. Maclay.*) Is there no system which the Government might adopt whereby they could consume the smoke?—Well, I have seen a great many systems tried for consuming smoke, and I am not myself satisfied that any of them are perfect. I do not know enough of the subject to be able to say one way or the other whether you could adapt any of these systems to the consumption of smoke in the boilers that have to be used in the steam vessel.

15470. Do you know any reason why the Government should not use that Yorkshire coal in times of peace, just as freely as they use the Welsh coal, except with regard to the matter of smoke?—No; if they merely want to move their ships about I do not know any reason why they should not; but I assume that a Government in time of peace must always have its armament in a condition to meet the requirements of war, and that therefore if they required to make their war-ships as invisible as possible, they would not like, if war suddenly broke out, to empty their bunkers of Yorkshire coal and put in Welsh. If I were the owner of a fighting machine which was kept for the purposes of fighting, and which had to be driven with coal, I should say, cost or no cost, I would use Welsh. As a South Yorkshire coal-owner I should be extremely glad to sell them South Yorkshire coal if they would use it.

15471. But, apart from the simple question of smoke, you know of no reason why they should not use it?—No, none; there is practically no difference between the two coals in effect.

15472. You would not like to say that the Government should be restricted to the use of Welsh coal?—No, except if I knew there was a big European war starting to-morrow I should be more satisfied as an Englishman to know that they had the best Welsh coal on board.

15473. But if you also knew that they might not be able to secure the best Welsh coal at every point——?—Then there is no earthly reason why they should not use ours; they would have to get coal of some sort.

15474. Do you know what class of coal the Russian Government use for their ships?—No, I do not.

15475. Nor any of the other Continental Powers?—I do not.

15476. (*Mr. Brace.*) I think it is briquettes that they use largely, and it is there that we are supposed to have the advantage of them?—Well, I do not know, and therefore I cannot give away any dangerous secrets for the benefit of foreign Powers.

15477. (*Mr. Maclay.*) You said you knew a good deal about the American wagons, although you have never visited America?—Yes.

15478. Can you express an opinion, from what you have heard, as to the reason why the Americans should continue to use those very large wagons on their different systems?—I think the Americans are quite right, and if a coal trade was being built up and created in England in modern times, as it has been in America, no doubt to some extent you would get the same type of wagon used here; but you must not forget that the circumstances of the two countries are entirely different. There you have a coal trade built up in comparatively recent times; they have had a free hand; they have had the benefit of other people's experience, and they have gone in for the best and the cheapest system, and they are a country of large distances, of large orders. We are a small country with our population scattered all over the place, and we must be a country executing small orders, I think, to a very much greater extent than America, and we cannot help it. Then, of course, it is a very serious matter indeed to go in for an alteration of your existing type of stock to any material extent. It involves the alteration by the trader of his plant, and he wants to see something in return for that; and it involves the alteration by the railway company or the dock company of the shipping appliances to enable them to deal with the new wagon, and they want something for that.

15479. You told us that the rate per ton from your district to Hull worked out at something like ½d. per ton?—Yes, a little over ½d.

15480. Do you know, roughly, how that compares with the rate to Manchester and Liverpool; is it about the same?—I will put the Manchester and the Liverpool rate in, as I said I would, instead of making a guess now.

15481. What is the distance from your district to Manchester and Liverpool?—Table B gives these distances. In that table the distances and rates are approximate averages. It is not possible to give them with absolute exactness. The distance to Manchester is less than it is to Humber ports; the distance to Liverpool is rather more. *Page 283.*

15482. Then you also stated that you had a graded rate, according to the quantity of coal shipped, from certain collieries?—We used to have a group rate many years ago. One of our collieries contended that the effect of that was to deprive them of the benefit of their geographical position; the matter came before the court, and the court decided that it was so. I think, strictly speaking, that was right and correct, and I do not really know that it has worked very much to our disadvantage one way or the other. Some collieries have got some benefit.

15483. (*Sir George Armytage.*) I suppose they contended for their geographical position?—Yes. It cuts both ways; if you have two collieries, one there and one there, going in this direction, this man pays rather more, but when you come to go in that direction, then the other man pays more.

15484. (*Mr. Maclay.*) In your district are there smaller and larger collieries?—Our district is mainly a district of large pits, but the older pits are not so large as the new ones. Scarcely any of the new pits will, when they are in full work, produce less than 1,000,000 tons per year. You see, you are obliged to have so much larger capital in consequence of the greater depth; you cannot get a greater profit per ton; as a matter of fact, you will get rather less on account of the increased depth, and therefore you must have a greater output in order to get interest upon your capital, and that involves a much larger coalfield.

15485. But is it not rather hard on the smaller collieries—say two collieries alongside each other, one large and the other smaller—that the smaller should be charged a higher rate perhaps than the larger colliery, simply because its output is not so great?—I have not suggested that that should be done. I said that I was sorry that the train load rate was not adopted by the Duke of Richmond's Committee, but I have not suggested that the large colliery, merely because it is a large colliery, should have a lower rate.

15486. (*Chairman.*) But I think what Mr. Maclay means is with regard to your reference to the Denaby and the Cadeby Collieries; you remember you spoke about a maximum quantity, or a certain quantity, giving a rate of 2d. less than another quantity?—In order to understand that rate, it is necessary really to know the circumstances. There was a railway promoted, 14 or 15 miles in length, from the Denaby and Cadeby Collieries to the Hull and Barnsley Company; it was a matter of great importance to the Hull and Barnsley Co. that it should be made, and it was a matter of great importance to the Colliery Co. that it should be made. Therefore the Hull and Barnsley Co. were empowered by special Act of Parliament to give a working charge on their undertaking, which enabled a given percentage to be paid on the estimated cost of the line. In order to make themselves secure they, of course, wanted a guaranteed tonnage, and in consequence the tonnage was guaranteed at a gradual scale, so that the Hull and Barnsley Co. were safe in entering into that arrangement.

15487. But with a minimum?—Yes.

15488. (*Mr. Maclay.*) Do all the collieries in your district have their own wagons?—Yes, we all of us have our own wagons.

15489. (*Mr. Young.*) I should like to ask you a few questions with regard to the fuel for the Navy. You see no reason, I presume, against using your coal instead

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of the Welsh coal in time of peace?—Well, as a coalowner, I see every reason for using it; I should like to sell it; it would drive the ships, but I cannot shut my eyes to the fact that the Government must always be prepared for war, and I cannot dispute the fact that for war purposes the Welsh coal is better than ours, because it produces a smoke which is less visible than ours.

15490. Do you not think that the question of probability or improbability has to be taken into consideration when you are dealing with a matter of this sort? Considering that for over 50 years the Fleet has never been called into action, do you think it is absolutely necessary to always have Welsh coal, and no other coal? —Speaking as an Englishman and not as a coalowner, I should say that the Government of this country would be criminally responsible if their Fleet was not ready to go to war to-morrow if it were wanted. It is kept and paid for by us as our great national insurance against risk; and I think, as a fighting machine, it ought always to be in the most perfect condition possible, and ready for use at a moment's notice, quite apart from pecuniary considerations.

15491. But have you ever known war to be precipitated in that manner without, say, a month's, or two or three months' notice?—I should not like to gamble for my existence upon that.

15492. But if in history, or, as far as our country is concerned, during the last 60 or 70 years you have never known, nor has there ever been, a case of the sort, where we have not had at least three or four months' warning that war was to break out, do you think it is necessary to have Welsh coal only?—Well, I know perfectly well that if I was a foreign Power, and was thinking of going to war, and that I could get an advantage by not giving any notice at all, I should do so.

15493. But is it possible, with the Press and the telegraph as we now have them, giving all the intelligence of importance to-day to all the world to-morrow, for a country to prepare for war and swoop down upon its enemy without anybody knowing anything about it?—I think my answer to that would be that those are matters of high policy really which are beyond the ken of a simple coalowner or wagon-builder, and they could only be answered satisfactorily by those who are responsible for the conduct of the affairs of the country.

15494. It is only that you to some extent as an individual, I think, form the policy of the country, and you have something to say about what the policy of the country is to be?—Well, I do not think my opinion is worth very much upon that. But I do say this, as an Englishman, that it is not a question of cost; pecuniary considerations should not enter into the matter at all, that Fleet of ours ought to be ready to defend this country at a moment's notice at any time. As a coalowner, I should very much like to sell my coal; as long as peace continues, I do not see any reason why they should not use it; they will very likely be driven to use it to some extent in war. But the best coal for fighting purposes undoubtedly is the Welsh coal, because it does not make the ships so visible as our coal does. It is not correct to say that it is smokeless, but it is not seen as ours is.

15495. That is without discriminating between actual war and times of peace?—I cannot go into that.

15496. I think you said that some time ago you used to send a considerable quantity of your coal to London? —We did.

15497. Do you send any now?—Yes, a large quantity goes to London.

15498. By rail?—Yes, that coal I was speaking of was coal for consumption at gasworks; it was sent in train loads, and there was a special rate for that purpose which was lower than the ordinary rate. Unless that low rate was continued we could not send the coal, because the seaborne coal drove it out of the market, and when the rate was raised to the ordinary figure we lost our trade, because we could not then supply in competition with the seaborne coal. Some of us tried it for a year, and we sent a considerable quantity of coal to London in order to retain touch with the trade, the result of the operation being a considerable loss on every ton sent. We did that for a year, and we found then that there was no hope of getting the trade back, and that the only thing to do was to let the trade go, which we did.

15499. Would it be fair to ask you to say what the railway rate was at that time?—There has not been very much change in the ordinary rate to London for a considerable number of years, except for that. You might take the rate from South Yorkshire to London as, say, 7s. 2d.; I should think that would be about it.

15500. What would be the rate for your competitors? —Their coal goes by sea; for instance, my friend Mr. Briggs could supply gas coal in London by sending it viâ the Aire and Calder, and by sea, and he could get it there at a less cost than I could by sending it by rail.

15501. What disadvantage would you be at now compared with the respective rates paid before?—I have not the figures with me, but I could supply them. There was a substantial difference between the old reduced gas coal rate and the rate for ordinary coal, and if I remember rightly it ranged from 1s. to 2s. less.

15502. (*Mr. Bell.*) With regard to railway rates, you say that whilst you would be glad to have a reduction in your rates, you do not consider them unreasonable? —No. I was speaking of the rates to the Humber ports.

15503. Yes. I think I remember a previous witness contending that mineral proprietors were entitled to greater consideration in regard to railway rates, because he considered that the railway companies enjoyed a larger percentage of their profit by carrying minerals at the rates which they were charging than they enjoyed by carrying any other portion of their traffic. Have you any opinion about that? Do you remember the evidence being given?—Yes, I read the evidence, and while I am not prepared to agree with the whole of the evidence which was then given, I think, put broadly, there is a considerable amount of truth in that proposition, and I do believe that mineral traffic, taking it all round, is the most profitable traffic that the railway companies carry. That is my belief; but the difficulty is that I do not believe there is any railway company in the kingdom which can tell you exactly what each particular class of traffic does cost them to carry, because their books are not kept like the books of any other business concern; there is no charge, there is no allocation of a very large portion of the expenditure between the different classes of traffic. Therefore the moment you attempt to arrive at what any particular class of traffic costs, you enter practically upon an inquiry which is full of doubt, and you do not know where you are—you have to invent some method of getting at it, and whatever method you invent, naturally the railway companies say it is not the right one; they are always prepared with conclusive figures to show that.

15504. You would not suggest that railway companies have any particular object in keeping their accounts in a manner which you describe as different from that of any other concern?—I am not quite so sure about that.

15505. Supposing there were a possibility of arriving at some definite data to show that minerals do pay a proportionately higher rate for carrying their traffic than is paid for other goods, would you consider that a fair justification for asking for some consideration?— I have not attempted to deal with the general question of railway rates, because I thought that really what I had to do here to-day was to deal with the possibilities of saving by improvements in the methods of carriage and I confined myself to that; but, speaking generally, I think that a number of our rates are high: there is no doubt about it; and I think that they might be reduced with advantage. But then I did not understand that that particular subject was a question for discussion by this Commission, and therefore I kept off it, and I merely considered the question of economies in transit; but as far as the export trade is concerned, I do say, and I think it is only fair to say, that I do not think it is an excessive rate. I should like to see it reduced, and I believe it would pay to reduce it, but I do not consider it an excessive rate.

15506. There are one or two answers which you have given which I did not understand quite clearly; you spoke about the rates for half a load being the same as for full loads?—No, I think not.

15507. Do the railway companies carry half truck loads of coal—orders for four tons, for instance?— They would do so, but I think you are under a misapprehension. I have not said anything about that.

15508. I misunderstood you, no doubt. Do you

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Mr. Frederick Parker Rhodes.

17 June 1903.

execute orders for half a truck of coal from your collieries?—We would do so, but the large proportion of that kind of order, so far as our own trade is concerned, is so small that you may practically leave it out of account.

15509. There is not much of that sort done?—No. Of course, rather than not sell four tons of coal, I would sell it. In that case I should take the wagon hire of the truck into account in fixing the price.

15510. But railway companies would carry half-truck loads at the same rate as train loads?—Yes, there is no difference, in point of fact, between the minimum figure, which, if I remember rightly, is four tons, and 40,000,000 tons, if you like—the tonnage rate is the same.

15511. Do you consider that railway companies give the same facilities for hauling colliery companies' trucks as they do for hauling their own trucks backwards and forwards?—In our own district I cannot say that there is very much preference given to the one over the other, unless in a case where a particular railway company is pressed for locomotive coal, and then naturally the tendency would be to rush its own trucks forward to get its supply; but, generally speaking, I have nothing much to complain of in that direction.

15512. There is no general complaint to that effect, you consider?—No, I think not. You see our district is served by different competing lines, and where you get competition between different railway companies you not only get civility, but you get attention, and it is not to the interest of either one company or the other to let the colliery service fall behind. If we were in the hands of one company solely, possibly we might get, and probably we should get, the same amount of civility, with not perhaps the same amount of attention; but at present the Midland are certainly not going to annoy me by keeping me short of my trucks and making it to my interest to put traffic either on to the Great Northern, the Great Central or the Lancashire and Yorkshire; and it is the same with the other companies.

15513. I suppose the Hull and Barnsley people could ship coal from 15-ton trucks, could they not?—I am not quite sure whether the appliances at the Alexandra Dock would deal with 15 tons or not. It is some years ago since I was there and saw them, but I think they could not.

15514. It is a question of cranes there, is it not?—Yes, they are all hoists. Really I should not like to trust my memory as to that without going and looking at them again. My impression is that they would want some alteration.

15515. Then really there has not been any progress in enlarging the trucks in your district to any extent?—Well, it would not be correct to say that, because the tendency for a number of years has been to gradually enlarge the trucks. They used to be much less than they are now, but the tendency has been, as the old trucks have gone out, to substitute 10-tonners in their place.

15516. But not beyond 10-tonners?—No.

15517. I notice that in the north the North-Eastern are running some of their traffic in, I think, 40-ton trucks?—Yes; if the North-Eastern Company, when the new dock is made, were to fit up that dock and make it capable of dealing either with 40-ton trucks, or with the standard trucks, and if it was worth the while of the colliery owner to provide the trucks, I have no doubt that then you would have a very considerable trade done in those trucks. But if the colliery owner is going to provide them, you must give him some benefit, and the benefit must be sufficient to make it worth his while to alter his place so as to take them. At our new colliery, which we are laying out at the present time, we are laying it out so that we can take either 10, 20, 30 or 40 ton trucks, but at our old colliery it would be a very difficult matter indeed; we should have to rip the place to pieces, practically, and re-build it.

15518. (*Professor Hull.*) I will ask you now to descend to a different subject. not about freights, but about the geology of your district. Are your collieries somewhere between Barnsley and Doncaster, and that district?—Roughly speaking, you may say the South Yorkshire Collieries are situated on the railways which run between Barnsley and Doncaster, Barnsley, Sheffield, and Worksop, and Sheffield and Doncaster, and the branches which connect with them.

15519. Generally in the district of the Don?—Yes, the river Don and the River Dearne both run through South Yorkshire, and unite at a point near Mexboro'.

15520. May I ask if any of your collieries are on the magnesian limestone?—The new colliery that we are sinking at the present time is not far from the edge of the magnesian limestone. Two of the other new collieries which are being sunk are going through it.

15521. On the Hull and Barnsley line, I suppose?—No, they would be the collieries which have been sunk to the east of the line which runs from Sheffield to Worksop. As a matter of fact, the magnesian limestone crosses that railway, or a kind of promontory juts out across it, at a point somewhere to the north of Worksop.

15522. Near Pontefract?—There you are getting on to the other side of the district; when we get to Pontefract we are getting there more into the West Yorkshire district.

15523. Your Barnsley bed is your principal one—the shallowest and the most important coal?—No, it is not the shallowest.

15524. I mean to say it is the most important of the upper seams, is it not?—Well, you cannot say it is the upper seam. I should say the Barnsley bed represented about the middle seam of the series. You have a number of beds above it, and you have a number of beds below it, but everybody who can get at it goes to the Barnsley bed, because it is the most satisfactory to work from a commercial point of view.

15525. Are you leaving much coal in the seams above; is there much of the overlying seams left?—Yes; they will probably come in at some future date.

15526. They are not being worked at the present time?—You cannot work them in competition with the Barnsley, except to a very small extent.

15527. Am I right in saying that the Barnsley consists of three divisions, upper and lower, soft and hard, and steam coal in the middle?—It varies in different parts of the district. In some parts of the district you have one portion of it nipped out or separated, and in others another portion; but all through you have the steam coal portion of it—the hard coal—which is what one goes for; that exists all through. But the softer portions of the seam are not equal throughout the district. On the Barnsley side of the district they are very much thicker and of better quality than they are on the Rotherham side. Personally I would just as soon be without them; if there was sufficient soft coal to hole in I would sooner the others did not exist.

15528. How do you separate the hard from the soft in the mine?—The men fill it separately, or they ought to fill it separately, and they do to a certain extent. There is no difficulty in separating it, because the appearance of the two kinds of coal is quite distinct.

15529. Which do they take out first—the top, and then rise up to the hard?—No; what you do as a matter of practical working is, you hole in the lower portion of the soft. Where you have got the full section of the seam, they utilise the upper portion of it as a roof for the time being, and get the seam down up to the Bags. Then as the face advances they get what they can with the Bags and the Day-Beds out of the break behind. Where the seam is thinner, and where those upper portions do not exist and are nipped out, then you hole in the Bottom Softs and get the whole seam up to the natural roof.

15530. What would be the average thickness of the Barnsley bed in your district?—I have been in it in my younger days where it was over 11ft. thick. In the newer portion of the South Yorkshire coalfield I should think you might take it at about from 5ft. 6in. to 6ft. thick. There is not very much difference in the thickness of the hards, but, oddly enough, where the coal is thickest, as a rule the softer portions are of the best quality—they are of better quality. In fact, when I was a boy the valuable part of the Barnsley seam was the soft portion of it, and the hards were the drug, and nobody knew what to do to get rid of them sometimes.

15531. The soft was more easily worked?—No, you worked the whole seam. But, of course, the adoption of coal for locomotive purposes and for thousands of other purposes has rendered the hard portion more valuable.

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15532. Do you think the seam is thinning eastwardly?—Yes. As I say, the softer portions disappear to a certain extent.

15533. (*Mr. Briggs.*) It is divided, is it not?—Yes; in another part of the district, where you go east from Monk Bretton or Carlton, you begin to get a dirt parting coming in, and that dirt parting very rapidly thickens until for practical purposes it becomes then two seams. You work the lower portion, and you cannot attempt to touch the other; it has to be left, and must be left; but that is the portion really which is practically not worth getting—it is not a good commercial article.

15534. (*Professor Hull.*) One general question so far as regards your idea based upon personal knowledge of that district: you do not know any eastern limit to the coal measures under the magnesian limestone in your formations?—No; as I say, if I am going to answer any question about that, I would rather consider the subject carefully, and not answer offhand; but at present the indications point to a very large extension of the South Yorkshire coalfield going east, and we do know that it has been proved at a point many miles away to the south-east, and that it exists there at a depth of something like 1,100 yards.

15535. That is the boring near Idlestop?—Yes.

15536. (*Sir William Lewis.*) You told us that there was no group rate at present existing, but that the whole of the collieries paid according to the distances to the port?—Yes.

Table B., page 283. 15537. Could you give us the nearest and the furthest of the collieries?—Yes. If you will allow me, Sir William, I will do what I said I would do, namely, put that in in reply to the Chairman's question in the shape of a little table, and give you the rates and the distances.

15538. And also the charge, if you please, per ton per mile, according to the particular distances?—Yes.

15539. Then with respect to the competing lines of the Hull and Barnsley and the North Eastern, do they serve the same collieries?—That requires a little explanation. The Hull and Barnsley Company reach some of the collieries direct with their own rails; they obtain access to other pits by means of the Midland, the Great Central, and the new Dearne Valley line.

15540. By running powers?—No; the traffic is handed over to them by those railways, except to some extent on the Dearne Valley.

15541. So that there is a change of engines?—Yes. Then the North Eastern Company by their own rails do not reach any colliery direct except those collieries which are situated on the Midland and North Eastern, Swinton and Knottingley joint line; there are two or three pits there, and in that way they do reach them. They obtain the coal from the other collieries by means of the Great Central or Midland Railway; but I believe they have the power to run their own engines on the Great Central Company's South Yorkshire lines, and I believe that in times of pressure they have done it up to the collieries; and they have power at the present time, I believe, to quote their own rates and to make their own arrangements.

15542. But as a fact both companies going to the rival docks at Hull are subject to a change of engines at some particular point?—Yes; except as I say, those few collieries which are reached by the two systems direct.

15543. Then when you get to Hull, the North Eastern have no right to run into the Hull and Barnsley dock?—No.

15544. And the Hull and Barnsley Company have no right to run into the old dock?—No; that story, and the reasons pro and con have formed the subject, I should think, of weeks of discussion in the Committee rooms.

15545. (*Sir George Armytage.*) Was not that one of the objects of making this new dock?—Yes; but the battles were about that railway for which powers were sought and which by a little loop line would have enabled the North Eastern Company to run into the Alexandra Docks. Of course there were a number of arguments pro and con, but Parliament always decided, and (if I may venture to say so without impertinence) rightly decided, that the North Eastern should not get into the Alexandra Dock under the then existing conditions. The Hull and Barnsley said, "You do not want to come in and help us, but you want to come in to murder us, and when you have murdered us you will do what you like with the body."

15546. (*Sir William Lewis.*) They might want to get in for the benefit of the traders?—They might, but it would have been a risky experiment, I think, for the Hull and Barnsley.

15547. Then with reference to train loads, is there no arrangement for train loads from any of the large collieries?—No.

15548. How many clearances per day do you get from the ports?—In practice a good deal of the traffic does come away in train loads for shipment already; but my point was that if there was any money inducement to do it a very much larger proportion might go in that direction.

15549. But you do not know what the average number of clearances is, say, for a colliery working 1,000 tons per day?—No; you see it depends so much upon what proportion of its output that particular colliery might be sending for shipment at the time. Take, for instance, our own colliery at the present time; we are practically sending nothing for shipment, the reason being that we are all well sold for inland purposes and for a special trade at Grimsby.

15550. But it is a matter that seriously affects the value of your wagons whether you keep them fully at work or not?—It is so. You may take it that, speaking generally, I do not know what the reason is, but it is an undoubted fact that the wagons do not work as well as they used to do; you do not get the same number of journeys out of the wagons that you used to get.

15551. (*Sir George Armytage.*) Do you mean you do not get them back so quickly?—Yes; and I think it arises first of all from the fact that the railways themselves have to cope with a very much larger traffic than used to be the case, and so far as the shipping wagons are concerned, a considerable proportion of them go round by Normanton; and whenever they go to Normanton there seems to be some delay.

15552. We had some statistics given us as regards the obtaining of wagons at Liverpool, by Mr. Barrett, I think it was?—Yes, I saw that. Mr. Barrett is a person who could give those statistics in his own case, and could do so accurately; but I have a strong impression myself that any statistics in the way of actual figures that I might attempt to give from our own district would, I am afraid, to some extent be in the nature of an estimate, and would be misleading—so many considerations come into effect. But I do know this, speaking as a person interested in the owning and working of wagons, that you cannot get the work out of the wagons that you used to do.

15553. I have no doubt you complain and make the railway company acquainted with it?—Yes, all of us do the same. We all of us employ somebody to look after our wagons, and his object is to continually keep addressing complaints to the railway company.

15554. (*Sir William Lewis.*) Could you give us your experience of working traffic over a railway which provides the wagons, as against working over a railway where freighters or colliery owners provide the wagons?—No, I could not give any useful experience in that direction, for this reason: the Midland Company serve us, and they, of course, supply wagons; but for all that we supply the great bulk of the wagons ourselves.

15555. (*Sir George Armytage.*) They go on the Midland line?—Yes; for instance, I remember perfectly well when the Midland adopted the policy of purchasing the wagons, I sold them at once all the wagons that belonged to a concern in which I was interested, and immediately gave orders for new ones.

15556. For the benefit of the wagon company?—And my own, too.

15557. (*Sir William Lewis.*) But I understand you are very emphatic with regard to the disadvantage to a colliery owner of being dependent upon a railway company for the supply of necessary wagons?—Personally, I would not be dependent upon, or in the hands of, a railway company on any account. I would sooner endure a considerable amount of inconvenience, and sooner submit to a considerable amount of increased cost than run the risk which I think is involved in that state of things.

15558. With reference to the increased size of wagons,

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Mr. Frederick Parker Rhodes.
17 June 1903.

would the increased dimensions necessary to carry 15 tons as against 10 tons involve a very serious expenditure in a large number of collieries in your district in the re-arrangement of the provisions for screening and tipping?—It would. As I said in the case of the older collieries, I do not think they could do it except at a very serious cost.

15559. The fact is that it would involve the lifting of the pit bank in many instances?—Yes. It is all very well to talk about lifting screens, but you can only do that up to a certain point; and if you attempt to do it beyond that point you not only have to lift your screens, but you have to lift your pit bank and to alter the whole of your arrangements on the surface. Your engine-house, and so on, is all adapted for a particular state of things, and if you interfere to any serious extent with any one of the conditions you have to alter all the rest.

15560. In addition to that, the expenditure at the port would also be a very serious one, as it would involve not only providing for those wagons of additional capacity, but concurrently with that, enabling the present standard wagon to be also used?—That is so.

15561. It would take years before the present wagons would be worn out?—That is so. Both parties would have, in my opinion, to spend a considerable sum of money to make any marked change in that direction. Therefore, it goes without saying that if they are to do it, the two parties who are to spend the money must each of them get some advantage out of it.

15562. Then assuming that that could be done by arrangement between the railway companies and the dock companies, and also that the railway companies are prepared to face it, you, after careful consideration, are not disposed to recommend going beyond 15 tons?—I would not say that, Sir William, but what I mean to say is this, that from the point of view of the trader, who supplies his own wagons, in my judgment the wagon that will give him the best return for his expenditure on wagons in the future, if his colliery is able to deal with them, and if the ports are able to deal with them, is the 15-ton wagon. From the railway companies' point of view again, if the colliery and the port can deal with them, I believe the still larger wagon would be the one that would give the best result; because there you would get the greatest proportionate increase in the load to the dead-weight of the train. But then that consideration which appeals to the railway company is not the consideration which appeals to the trader, unless he is going to share in the benefit.

15563. No. The other point you mentioned incidentally was the seriousness of having a 40-ton wagon lying idle in the same siding, or the difference between having a number of 40-ton wagons and 10-ton wagons lying idle?—Yes; you could only have them for the special trade, where you would be quite sure that they would work, and work regularly.

15564. Then the introduction of the 40-ton wagon would involve the re-arrangement of the sidings of the collieries?—Yes; in the case of the bigger wagons it would mean the alteration, as I say, of the whole of the surface arrangements at the colliery.

15565. You were asked something about the American trade. Although I understand you have never been to America, I take it you have made yourself acquainted with the fact that there are very few ports in America which deal with 40-ton wagons?—That is so; there is one port, Norfolk, where I believe they are laying themselves out to deal with that type, and to do a largely increased trade.

Professor J. D. EVERETT, F.R.S., called; and Examined.

Professor J. D. Everett, F.R.S.
17 June 1903.

15566. The Witness put in the following statement:—

(1) I have been Secretary of the Underground Temperature Committee of the British Association since its appointment in 1867, and have drafted the 22 reports which have appeared. The reports contain accounts of observations taken under the direction of members of the committee, or with instruments furnished by the committee, and also accounts of the most important observations that have been taken independently of the committee.

(2) In connection with the report for 1882, I published a Summary of the results obtained up to that date, with a discussion of the principles involved. The average rate of increase which I deduced in the Summary was 1° F. for 64ft., but in the report for the following year, in consequence of further information received from the geologist of the St. Gothard Tunnel, I diminished the number of feet per degree assigned to that locality from 82 to 57·8; and this change, along with a similar change for the Mont Cenis Tunnel, altered the general average to 1° in 60ft., which I regard as the best average obtainable up to that date (1883).

(3) The observations in the Schladebach bore (near Leipsic) were described in the 1889 report. They were taken under remarkably favourable conditions, at intervals of 30 metres, from 6m. to 1,716m., or 5,630ft., and showed a remarkably steady rate of increase, which is 1° F. in 67ft., when calculated by direct comparison of the two extreme points in the series. Herr Dunker, under whose direction the observations were carried out, deduced 1° F. in 65ft., by applying the method of least squares to the complete series.

(4) A bore at Paruschowitz in Silesia is 200m. deeper, and observations taken in it are described in the 1901 report; but they were taken under much less favourable conditions than those at Schladebach. The temperature at the lowest depth, 1,959m. or 6,428ft., was definitely determined to be 69·3° C., or 156¾° F.; but the temperature at 6m., with which this is to be compared, is open to doubt. In the official account it is taken as 12·1° C. (as against 10·4° C. at Schladebach), and the rate deduced is 1° F. in 62·2 ft. Comparison with the temperature of neighbouring towns as given in Hann's Meteorology suggests 8·3° C., as a more probable temperature at 6m., and this would give 1° F. in 58·3ft. Perhaps 1° F. in 60ft. is the most probable deduction.

(5) A specially good determination in a well 4,500ft. deep at Wheeling, in Virginia, is described in the 1892 report. It gave a mean increase of 1° F. in 74ft., the well being dry except that a little water leaked in at about 3,000ft., and accumulated at the bottom. Two years later, the well, which had been in the meantime sealed up, was reopened, and found full of water. Observations were taken in the water from 1,586ft. to 3,196ft., and found to agree to 0·2 of a degree with those previously taken in air—a very severe test of accuracy.

(6) Certain erroneous statements respecting underground temperature appear to have gained a footing in popular text-books.

Mr Bramall in his evidence before this Commission (Question 330) alludes to "the usual theory that, irrespective of what the strata may be, there is a certain rise of temperature for every certain number of feet that you go down into the earth." No such theory is maintained by anyone who knows the facts. The rate of increase certainly varies from place to place, and for different depths at the same place.

(7) Lord Kelvin's view, that the earth is a body which was once red hot and is still cooling, does not involve a uniform gradient of temperature, but indicates that large differences of gradient are to be expected, as a consequence of the large differences in the conducting powers of different rocks. According to Prof. Herschel's experiments, shale conducts more than twice as well as coal, and limestone nearly three times as well as shale. In going down vertically through a succession of horizontal strata, the step for 1° of increase should be directly as the conductivity, as a consequence of the assumption that the same upward flow of heat goes on in all the strata. In comparing two places which are far apart the rule does not apply, because the upward flow of heat may be different at the two places.

(8) Again, in Questions 1654 and 1655 of his evidence before this Commission Mr. R. Martin states that in most mining text-books a temperature of 50° at the depth of 50ft. is taken for granted; and in Question 1920 Mr. H. W. Martin says: "A very generally accepted opinion is that the temperature of the crust of the globe over these islands is fairly uniform at a depth below the surface of 50ft., and is 50° F." Now, the temperature at the depth of 3ft. (and also at some greater depths, which I omit for brevity) has been

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determined with great accuracy by several years' observation of large thermometers planted in the earth with their scales above ground at three stations in Edinburgh, and also in the grounds of Greenwich Observatory. They show that the mean temperature at 3ft. is about 51° at Greenwich, and about 46° at Edinburgh; a difference of 5°. The temperatures at 50ft. will differ by about the same amount.

(9) There is a prevalent notion that the mean annual temperature is the same at all depths in the ground down to 50ft., and increases from that depth downwards. Such a state of things would imply that heat flows upwards till it gets within 50ft. of the surface, and then flows no further, but mysteriously disappears. The reason why 50ft. was taken as a convenient starting point by early investigators was that this is about the shallowest depth at which a single observation suffices to give the mean annual temperature. The constant temperature at 50 ft. is certainly higher than the mean temperature at 3ft., otherwise the heat would not be able to complete its flow to the surface. The rate at which the temperature is likely to increase in going deeper in any particular colliery must be determined by observations taken in the colliery itself, or its immediate neighbourhood.

(10) I have been in the habit of regarding the East Manchester coalfield as one in which the increase is exceptionally slow; and in the 1882 report I have attributed this feature to the large quantity of water contained in its strata.

(11) Observations skilfully taken in the Durham and Cumberland collieries, under the direction of Prof. Lebour, gave steps of 57·5ft., 49ft., and 45ft. per degree. The 57·5ft. step was deduced under specially favourable conditions, being obtained by boring down 863ft. below the bottom of a mine in South Hetton Colliery, giving a total depth of 1,929ft. The 49ft. step was obtained in Boldon Colliery, with a depth of 1,514ft., and the 45ft. step from workings under the sea at Whitehaven Colliery, at 1,250ft. below ordnance datum, with 12 fathoms of sea overhead.

15566.* (*Professor Dickson.*) You have given us the result of your long continued work on underground temperatures so far as England is concerned, and, of course, especially so far as the coalfields are concerned, but are you able to give us, for any one coalfield, the rate of increase in temperature as you descend?—I am not prepared to give off-hand an accurate statement. In the Summary which I will put in, which was published in 1882, I give you the results for coalfields.

Summary.

The mines of the Société Cocqueril at Seraing (Belgium), with a depth of 1,657ft., give an average rate of 1°. F. in 50ft. The rock is coal shale. Professor Herschel found for shale the low conductivity of ·0019.

The mines of Anzin, in the north of France, with a depth of 658ft., gave in the deepest shaft an increase of 1° in 47ft.

Rosebridge Colliery, near Wigan, with a depth of 2,445ft., gave a mean rate of 1° in 54ft.

The four following are in the East Manchester coalfield:—

Astley Pit, Dukinfield, with a depth of 2,700ft., gave 1° in 72ft.

Ashton Moss Colliery, with a depth of 2,790ft., gave 1° in 77ft.

Bredbury Colliery, with a depth of 1,020ft., gave 1° in 78·5ft.

Nook Pit, with a depth of 1,050ft., gave 1° in 79ft.

Denton Colliery (Lancashire), with a depth of 1,317ft., gave an increase of 1° in about 77ft.

South Hetton Colliery, Durham, with a depth of 1,929ft., including a borehole at bottom, gives very consistent observations at various depths, and an average rate of 1° in 57·5ft.

Boldon Colliery, between Newcastle and Sunderland, with a depth of 1,514ft., and excellent conditions of observation, gives an average rate of 1° in 49ft.

Whitehaven Colliery (Cumberland) in workings under the sea, with a depth of 1,250ft. beneath sea-level, or about 1,178ft. beneath the sea bottom, gave an increase (from the sea bottom) of about 1° in 45ft.

Kingswood Colliery, near Bristol, with a depth of 1,769ft., and remarkable consistency between observations at various points, gives 1° in 68ft.

Radstock Collieries, near Bath, with a depth of 1,000ft., give a doubtful average of 1° in between 60ft. and 70ft., the results in different parts being irregular. We have adopted 1° in 62ft.

Fowler's Colliery, Pontypridd, with a depth of 855ft., gave, by one observation at the bottom compared with the known surface-temperature, a rate of 1° in 76ft.

Professor J. D. Everett, F.R.S.

17 June 1903.

Professor Phillips' observations in Monkwearmouth Colliery, published in "Phil. Mag." for December, 1834, showed a temperature of 71·2° in a hole bored in the floor of a recently exposed part at the depth of 1,584ft. The surface of the ground is 87ft. above high water, and the mean temperature of the air is assumed by Professor Phillips to be 47·6°. If as usual, we add 1° to get the soil temperature, instead of assuming, as Professor Phillips does, that the temperature 100ft. deep is identical with the air temperature at the surface, we obtain a rate of increase of 1° in 70ft.

I wish to call the attention of the Commission to the difference of that South Hetton case from the results obtained in the East Manchester coalfield, which I believe have come before you with special fulness This observation in South Hetton Colliery was taken under favourable circumstances; besides taking observations in the mine itself with proper instruments and precautions, they took advantage of a hole, about 800ft. deep, bored down from the bottom, and these observations are the mean of the whole.

15567. Was that bore-hole dry, do you remember?—I will give you the exact particulars. The hole was 2¼in. in diameter, and was bored out of the pumping side of the South Hetton shaft, in order that the bore-rods might be the more readily altered. The depth of the shaft is 1,066ft., that of the bore-hole 863ft. from the bottom of the shaft, or 1,929ft. from the surface of the ground. The section of the boring (not including the shaft) consists of 123 alternating beds of shale and sandstone, with occasional thin seams of coal and some fireclays. The bottom of the boring has reached a very coarse white grit, which is supposed to be the topmost bed of the millstone-grit series. The bore was dry at the time it was made, but it has since become filled with water, probably derived from the shaft above it. Streams, in fact, pour down the shaft and play about the hole.

15568. I wanted to have a general expression of your opinion. Is there a very great difference in the temperature gradients in different coalfields in England?—Certainly there is. If you want to get any trustworthy information as to the depth at which a certain temperature will be reached in a certain place, you must base your deduction upon observations made at that place and immediately contiguous places.

15569. And it is not safe to argue from one place in England to another?—No; the rate of increase will be about as 2 to 3, perhaps, comparing one coalfield with another.

15570. Do you think it is possible to get from the recorded deep borings a gradient which will give us some useful information as to the temperatures likely to be met with in mines?—Certainly; and also they give us information as to whether there is likely to be any great difference in the rate as the depth alters. The conclusion from those very deep bores on the Continent is that on the whole the rate is about the same; it sometimes gets a little faster and sometimes a little slower, but on the whole the rate is the same at greater depths as at more moderate depths.

15571. You are not in favour of the view that the rate diminishes as you go down?—No; you will find cases where it does, and you will find cases where it is the opposite. The best average is to take the curve as a straight line.

15572. Are you familiar with any of the recent observations taken in the Simplon Tunnel?—No; I have made attempts, but there are very few libraries in London where you can get them.

15573. The Commissioners had evidence from Professor Albert Heim, of Zurich, on the point. His results agree fairly well with the results from the deep shafts that have been sunk?—I am familiar with the observations taken in the Mont Cenis Tunnel, and still more with those taken in the St. Gothard. Are they the same?

See Appendix III. to First Report Vol. II.

15574. No, they differ from the St. Gothard. The results anticpated from the gradients which were calculated from the St. Gothard observations have not been found to be true in the case of Simplon, and the temperature is really higher in the Simplon?—Of course, the

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Professor J. D. Everett, F.R.S.

17 June 1903.

Simplon is a greater distance from the surface, 7,000ft. as against 5,000ft.

15575. Exactly. I want to put one question about the mean temperature to which you referred. The first point is that in the British Islands it is not correct, as I understand from your observations, to take a mean temperature of 50°, but it should vary from about 51° at Greenwich to something like 46° in the Scottish coalfields?—Yes; but I think that 51° at Greenwich is rather exceptional. It seems to be owing to the sandy quality of the Greenwich hills.

15576. You would put it a little lower?—I would put it at 50° in the vicinity of London, and in the vicinity of Edinburgh I should put it at 47°.

15577. I think you say, in one of the reports sent in, that 1° Fahr. should be taken off for every 300ft. above the sea?—Certainly. With reference to the mean temperature of the air, it has been thoroughly established that over the British Islands 300ft. of ascent makes on an average a difference of 1° in the mean temperature of a place. The exceptions are very trifling. What is true of the mean temperature of the air will also be true of the mean temperature at a small depth.

15578. Some of the witnesses have, I think, stated that at a depth of 50ft. below the surface you come to a temperature which is approximately the mean temperature of the air. Do you agree with that?—Not exactly.

15579. It is not exactly true?—No. The state of things is this: First of all, let us come to the mean annual temperature at a small depth, such as 3ft. It is found generally to be a little higher than the mean temperature of the air—but that is doubtful. The Meteorological Society adopt the simple arithmetical mean of the maximum and minimum. That is obviously too high; but even with this reckoning it is generally found that the mean temperature of the first few feet of soil is, on the average of all soils and localities, 1° higher than the mean temperature of the air. But that difference varies greatly according to the soil. With dry sandy or gravelly soil the difference will be greater than in wet or clay soil. Then, again, if you go to a greater depth, such as 50ft. or 60ft., you must allow for the regular increase of temperature; it will be a little higher, because the heat has to get out of the ground somehow. The fact that the temperature increases as you go down from 50ft. to 500ft. shows that the heat is creeping up; if it stopped anywhere it would create at that point an enormous temperature. It cannot get out, unless there is a gradual fall of temperature, until it gets to the very top.

15580. Would you put at as much as 2° Fahr. the difference in the temperature found at 50ft. below the surface and the mean temperature of the air?—That would be a fair average, I think, for the British Isles. There is an uncertainty of a degree or more about it, according to what place you happen to be at; but, taking one place with another, I think that is about the average.

15581. There must be a difference?—In writing these reports I often had to assume the most probable surface temperature of the ground; and I went on the plan of getting the best information as to the mean air temperature, which usually had been observed somewhere in the neighbourhood, and then I added 1° to that. I have looked into the matter since, with the literature available at the Meteorological Society's office, and that view is still confirmed.

15582. If you take the temperature at 50ft. down, you take off 2° from that to obtain the mean temperature of the air?—Yes, somewhere between 1½° to 2°.

15583. (*Mr. J. S. Dixon.*) How do you account for the considerable difference of 3° between London and Edinburgh?—Because Edinburgh is further north, and we naturally expect the North Pole to be colder than the Equator.

15584. That is the reason, you think?—Yes.

15585. Have you any reason to account for these varying temperatures at the same depths between the West of England and the East of England? You gave us some with a rise of 1° for 57ft., and others for 78ft.?—These are the rates of increase.

15586. Can you account for that?—Oh, yes, certainly. In the first place, where water has facilities for percolating, that will tend to equalise the bottom and the top, and tend to make the rate of increase slow. In the second place, where there is no percolation of water, and where the soil is extremely non-conducting, that will tend to make the increase quick. The following remark is more precise still, and more certain: Suppose you have a non-conducting stratum a few hundred feet thick, immediately underneath a good conducting stratum a few hundred feet thick, both horizontal, and no water creeping through, it is certain that the rates of increase in the two will give a measure of the relative conductivities. If one has double the conductivity of the other, it will have twice as long a step.

15587. If a coalfield is dry, it will be hotter than one that is wet?—Certainly; and I think that bears upon the slow increase in the East Manchester coalfield. Mr. Garside supplied me some years ago with information as to the great abundance of water in that coalfield, and maintained that that was the chief reason why the increase was especially slow in the East Manchester coalfield. The information given in my 1882 Report is as follows:—"The secretary has had a correspondence with Mr. Garside respecting the quantity of water found in the East Manchester coalfield. This quantity is very large, as appears from a list furnished by Mr. Garside of the number of gallons pumped per minute from each of 13 pits during the sinking, the list being given on the authority of William Seddon, Esq., mining engineer, who was contractor for the sinking of them. The average is 360 gallons per minute for each pit, the highest being Denton Colliery with 1,000 gallons, and the lowest Valley Pit, Denton, with 120 gallons. Particulars are also given of the quantity now pumped from some of the collieries, amounting in some cases to 800 or 900 gallons per minute. Some of the collieries have been repeatedly flooded, and one is mentioned (Lord's Field Colliery) which was abandoned on account of water though its owners were makers of hydraulic machinery, and tried their utmost to keep the water down. Some of the pits were formerly the sources of water supply for towns in the district. In Astley Deep Pit, Dukinfield, the shaft is 'tubbed' with cast-iron rings to keep the water back; and most of the shafts in the district are made as watertight as possible. Mr. Garside refers to the 'Memoir of the Geological Survey round Oldham,' as stating, on page 45, that 5,000,000 gallons a day are estimated as being raised from the new Red Sandstone. The question naturally arises whether this abundance of water does not exert a powerful convective action, and furnish the explanation of the slow increase of temperature downwards, which has been observed not only in the coal mines of this district, but also in a still more marked degree at the Liverpool waterworks at Bootle." I may further state this: the slowest increase anywhere well established is at Liverpool, where the observation was taken by Mr. J. F. Deacon, the eminent engineer; the increase there was about 1° Fahr. in 130ft. But that was in a place where the soil was percolated by water—the water was gradually creeping up.

15588. (*Professor Hull.*) Are you aware that the position of the strata of the coal measures in the East Lancashire coalfield is very different from what it is in West Lancashire? Are you aware of that fact?—I do not know much about West Lancashire except Rosebridge.

15589. Say the Wigan district?—I know at Wigan the strata are nearly horizontal, and at Dukinfield they dip about 15°.

15590. Are you aware that all along the Oldham district, Stalybridge, and so on, the dip is comparatively high? Do you not think that that would account, to some extent, for the difference of the rate of increase of temperature?—Certainly.

15591. You may take my word for it, because I know it as a fact—The steeper the dip, the slower is likely to be the rate of increase, partly because it facilitates the flow of water, and partly because in general any kind of lamina red rock conducts better along the planes of lamination than across them. In my "Summary" I apply that result to Dukinfield, and show that it accounts for only a small part of the observed difference.

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(*Professor Hull.*) I did not know that there was any water in the Dukinfield pit, certainly not at the depth at which the observation was taken. I am sure there was not.

15592. (*Sir George Armytage.*) Have you formed any opinion as to the limit of mining due entirely to high temperature?—I think I had better confine myself to facts within my own knowledge; I am not a practical miner, I have only been in a mine once or twice in my life. It appears to me it is largely a question of money, and if you are prepared to pay any amount of money for the labour, you can go to a very great depth.

15593. That is to say, if you are prepared to pay any amount of money for the ventilation?—For instance, I suppose the Commission are aware of the state of things in the Comstock load, and the conditions under which the miners were working there? I will just read you a few extracts that I have on the subject, taken from the United States Geological Survey Report, 1883, Vol. IV., the author being Eliot Lord. One of the chapters (xix., pp. 389-406) is entitled "Pains and Perils of Mining," and it describes the high temperatures of the Comstock Mines and the sufferings of the miners:—

"In the 1,400ft. level of the Crown Point Mine a stream of water gushed from a drill-hole in June, 1873, so hot that eggs could readily be cooked in it; yet before the end of the year, with the slackening of the waterflow, the temperature of the level fell many degrees. Up to the end of 1877 the highest recorded water temperature was 154° Fahr., and large sections of the lode rock at the 2,000ft. level had a nearly uniform temperature of 130°. The highest water temperature previously noted in other mines was 125° at the Huel Clifford, in Cornwall. During the past three years an increase in water temperature to 170° has been recorded. Of late years heat has killed strong men in almost every deep mine on the lode, and in some mines the deaths so caused have been frequent. The hot water which spouted from the rocks stood in deep pools at the bottom of inclines or the foot of shafts. William Jenkins was taken from the sump of the Julia mine shaft in February, 1879. Though immersed only a few seconds in the water, whose temperature was 158°, he was literally flayed alive." Then it describes the effect of the heat on health, and to some extent it means good health, as it makes them sweat and purifies their skins. There is a Table given of temperatures taken in the principal shaft with the best instruments from 100ft. down to 2,100ft. from the surface.

This is the Table:—

Ft.	Fahr.	Ft.	Fahr.
100	50½	1,200	89¼
200	55	1,300	91½
300	62	1,400	96½
400	60	1,500	101
500	68	1,600	103
600	71½	1,700	104½
700	74½	1,800	105½
800	76½	1,900	106
900	78	2,000	111
1,000	81½	2,100	119½
1,100	84		

At page 387 an account is given of how the men work: "The men throw off their clothes at once. Only a light breech cloth covers their hips, and thick-soled shoes protect their feet from the scorching rocks and steaming rills of water which trickle over the floor of the levels. Except for these coverings they toil naked, with heavy drops of sweat starting from every pore. If woollen garments are put on they soon cling to the body in hot dripping folds, irritating the flesh and checking the natural evaporation, until the blood courses feverishly through the arteries, the veins swell, the skin itches unbearably, and the wearer tears off the irksome clothing as if it were in truth the shirt of Nessus. Yet, though naked, they can only work at some stopes for a few moments at a time, dipping their heads repeatedly under water showers from conduit pipes, and frequently filling their lungs with fresh air at the open ends of the blower tubes. Then they are forced to go back to stations where the ventilation is better, and gain strength for the renewal of their labour. For the sake of high wages and the information which gamblers prize, men were willing to suffer this heat and continue the search for ore."

As pertinent to the present inquiry, I have prepared the following Tables:—The first is a list of the deepest observations of temperature known to me in mines and vertical borings. The next two give the depths at which the temperature of 100° F. was actually found in some of these sinkings, and the calculated depths at which it would be found in the others. The observations in question, with the exception of those at Pendleton, have all been described in my Underground Temperature Reports, and the dates of the British Association volumes in which they are contained are indicated. The fourth gives the mean temperature of the surface soil at the nearest stations to coalfields that I have been able to select from the publications of the meteorological societies, together with observations at Ashton directly furnished to me by Mr. Garside.

Professor J. D. Everett F.R.S.

17 June 1903.

TABLE I.

	Temp. Fahr.	Depth (feet).	Feet per degree of increase.	British Association Report for.
Paruschowitz (Silesia)	157	6,445	60	1901
Schladebach (near Leipsic)	134	5,630	67	1889
Sperenberg (near Berlin)	116	3,492	51½	1876
Wheeling (W. Virginia)	110	4,462	74	1892
Pendleton (near Manchester)	100·6	3,480	66	—
Port Jackson (N.S.W.)	97	2,733	80	1895
Rosebridge (near Wigan)	94	2,445	54	1870
Dukinfield (Manchester)	86½	2,700	72	1880
Ashton Moss (near Manchester)	84	2,880	82	1881
Tamerack (Lake Superior)	84	4,450	100	1901
Scarle (Lincolnshire)	79	2,000	69	1876
Kingswood (near Bristol)	75	1,769	68	1879

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Professor J. D. Everett, F.R.S.

17 June 1903.

TABLE II.

Depths at which 100° F. was found.	Feet.
Sperenberg	2,400
Paruschowitz	3,200
Schladebach	3,400
Pendleton	3,480
Wheeling	3,875

TABLE III.

Calculated depths at which 100° F. would be found.	Feet.
Rosebridge	2,769
Scarle	3,449
Kingswood	3,469
Dukinfield	3,672
Wheeling	3,722
Ashton Moss	4,192

TABLE IV.

Surface Soil Mean Temperatures.

England.		Near Edinburgh.	
Camden Square, London	49·2	Joppa	46·1
Ashton-under-Lyne	46·5	Nookton	47·6
Bolton	49·2	East Linton	47·7
North Thoresby (Lincolnshire)	49·2	Smeaton	47·9
Rounton (North Yorkshire)	47·3		

Mr. J. STEPHEN JEANS, called; and Examined.

Mr. J. Stephen Jeans.

17 June 1903.

15594. (*Sir George Armytage.*) Would you kindly state your qualifications?—I have been for 27 years Secretary of the British Iron Trade Association. I was for about 17 years the Secretary of the Iron and Steel Institute. I have visited collieries and ironworks in pretty nearly every country in the world where they are to be found, and I am afraid I must plead guilty to having written a good deal on the subject of railway transport and kindred matters.

15595. Will you kindly read your statement and enlarge upon it if you think fit as you go along?

(1). The subject of economy in the consumption of fuel is one of the greatest importance to the iron industry, which is vitally affected by the supply and the cost of suitable fuel. The iron trade in its collective capacity has for many years past been the largest individual source of coal consumption in this country. At the time when the Report of the Argyll Coal Commission was made, in 1871, the total annual output of British coal was computed at 117,000,000 tons. Of that output, not less than 32,000,000 tons were consumed in the iron and steel industries, being 30 per cent. of the total output. Since then the relative consumption of coal in the iron trade has fallen off, partly in consequence of the vast increase of the relative importance of coal exports, and partly because steel has very largely taken the place of wrought iron, with a much reduced consumption of coal per unit of output.

(2). The average consumption of coal per ton of finished iron, in the palmy days of the finished iron industry, was about 3 tons (it was taken by the Argyll Commission at 3 tons 7 cwt.), whereas the average consumption of coal in the steel industry per ton of ingots is not more than, say, 12 cwt. with some addition to the consumption for finished materials. Probably an average of 15 cwt. will represent the coal consumption per ton of plates or rails throughout. Twenty years ago the total output of finished iron in the kingdom was over 2,500,000 tons. To-day the output is under 1,000,000 tons, so that the coal consumption is reduced to perhaps 3,000,000 tons. The output of steel, however, has in the same interval increased from 1,780,000 tons in 1881 to about 5,000,000 tons in 1902. Assuming an average of 15 cwt. of coal per ton of finished steel, this would mean a total coal consumption of some 3,750,000 tons; but, of course, had this been finished iron instead of finished steel, the total coal consumption involved would have been nearer 15,000,000 tons.

(3). In 1882 I read a paper before the Iron and Steel Institute on "The Consumption and Economy of Fuel in the Iron and Steel Manufacture," in the course of which I showed that since the end of the 18th century, the consumption of coal per ton of pig iron produced in this country has fallen from 9 tons 10 cwt. as a maximum to less than 2 tons as a minimum. There are records of that high figure, but it does not purport to be the average by any means. I pointed out that if the average consumption of coal per ton of pig iron had remained the same in 1881, as it was in the recorded cases available from 1791 to 1831, the output of pig iron in that year would have called for 58,500,000 tons of coal, whereas the actual consumption in that year was only a trifle over 18,000,000 tons. The economy of coal in the pig iron industry has not since then continued on the same scale of magnitude. The difference is now very inconsiderable as between one year and another. The best record for any single year has been 2 tons of coal per ton of pig iron produced for the country as a whole, and the best record for a particular district has been 1·8 tons per ton of iron produced during the year. Since 1873, which is memorable as the year of the great coal famine (when the cost of fuel reached a level not attained before or since), the average consumption of coal in the pig iron industry per ton of pig, has been reduced by just about half a ton, which means about 4,000,000 tons a year on our total iron output. Theoretically, this consumption should be still materially reduced, not only by bringing to a lower level the absolute quantity of coal used to smelt a ton of pig iron, but also by getting a greater useful effect out of the coal used through the blast furnace gases, in raising heat for other purposes, and thus displacing fuel that would otherwise be needed for power requirements.

(4). Much has been done in the iron trade of late years to bring about economy of fuel, and there are very few iron or steel works that have not made experiments of their own, designed to reduce the fuel bill. There are those who do not think that in daily practice much increase of economy is possible in either pig iron or steel-making, but this is a problem to which no one can provide a reliable solution in the light of

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past experience, except upon the ground that the possible margin of economy has been greatly reduced.

(5). The future of the iron trade is also a matter involved in much uncertainty. It is believed by some writers, including Mr. Edward Atkinson, and the late Mr. Abram S. Hewitt, both of the United States, and both very well known economists in that country, that the consumption of pig iron will in the next 20 years be 20,000,000 tons more than it is to-day. If that should happen, the future may call for a further large development of the British iron industry, based mainly on imported ores from hitherto relatively undeveloped fields, such as those of Norway, Portugal, Sweden and Greece. Any such extension of ironmaking operations would, of course, be attended by a large increase of coal consumption.

(6). In 1870 the total quantity of coal consumed in the iron trade, as computed by the Argyll Commission, was rather over 32,000,000 tons, which was 30 per cent. of our then coal output. In 1881 it was calculated that the proportion of our total output taken by the iron trade was 22 per cent.

15596. That was your calculation, was it?—Yes, that was my calculation.

It is probable that at the present time the iron trade does not absorb more than 17½ per cent. of our total coal output, but it is not because the iron trade has materially declined in the interval, for I estimate the total coal consumption of to-day would probably be less than a million tons under the coal consumption of 1870, despite the great economies effected. The change of conditions is rather due to the greatly increased relative demands of exports, shipping, gas, locomotives, etc.

(7). Up to the present time it can hardly be said that any important iron-making district in this country has greatly suffered, or is now suffering, from an absolute scarcity of coal supplies. But a scarcity of cheap coal has been threatened in several of the more important districts, including Lanarkshire, the chief centre of the Scotch iron and steel industry; Durham, which supplies the Cleveland Iron and Steel industries with fuel; and the South Staffordshire and one or two other Midland centres. A careful estimate which I prepared some 26 years ago, of the available supplies of coking coal in South Durham led to the conclusion that at the then rate of exhaustion, which was about 4,500,000 tons of coke annually, the South Durham coking coal would not last more than 130 years. Since then, the coke output of the Durham region has not been much increased, and it now varies between 4,500,000 and 5,250,000 tons annually. The question need not cause serious anxiety for another quarter of a century perhaps, but meanwhile the value of a limited and increasingly necessary commodity is well understood, and prices are not likely to fall much if at all. The price of coke over the last five or six years has been much over the average of the 10 preceding years. In the United Kingdom the total quantity of coke produced is, as nearly as can be ascertained, about 11,000,000 tons, of which about 5,000,000 tons are produced in the Durham and Northumberland fields, and the remainder in Yorkshire, Glamorganshire, Lancashire, Derbyshire, etc.

15597. (*Mr. Brace.*) Would you not say also Monmouthshire, because there is a good deal of coke produced in Monmouthshire?—That is quite true. I used the phrase "etc." to cover other fields.

Probably 7,000,000 tons are consumed by pig iron makers, and the remainder will be largely used in foundries, a certain quantity being exported. The pinch of scarcity is likely to be first felt in coking coal, of which the supply is limited. Already there are many complaints that coke is much inferior to the supplies of 20 years ago. Coal suitable for coking should cake readily, and should be as free as possible from sulphur and ash. The necessities of our own industry would seem to render the export of coking coal, or of coke, as such, very undesirable.

(8). It does not seem probable that we shall see in this country such an increase in the demand for fuel in the iron and engineering industries as we have seen in the past. The circumstances of the present time do not favour the hope of a much increased output of pig iron, and although we may materially increase our steel output and our foundry and mechanical industries, these do not relatively consume much fuel. The coal used per ton of castings does not exceed 4 to 5 cwt., and in relation to the value and the cost of the work, the consumption of fuel in engineering works is small, and tends to become relatively less, as a result of mechanical improvements.

(9). The present cost of coal in this country is much the same as in Germany, and less than in France or Belgium, but coke is relatively dearer here, partly as a result of the slowness with which bye-product ovens have been adopted. Our coke manufacturers have hitherto been afraid that bye-product ovens would injuriously affect the quality of the coke, but that is not now a matter for such anxiety as it was some time ago.

(10). Much has been done in this country of late years to economise in the process of smelting pig iron by a more complete utilisation of the waste gases of the furnaces. When I read my paper before the Iron and Steel Institute in 1882, there were 70 blast furnaces still left in Scotland with the open top, whereby the gases were allowed to escape into the air. Since then all these furnaces, excepting one ore two, have been fitted with close tops, and elaborate arrangements have been made, whereby all the residual products of the previously waste gases are utilised. A good deal is now being done to carry this movement still further by applying surplus gas to the driving of gas engines for power purposes.

So far as the future consumption of coal in the iron industry is concerned, it is difficult to say what it may be, as the consumption of coke in blast furnace practice ranges from 16 cwt. to 32 cwt., depending on the character of the fuel and the conditions of its use, including, of course, the degree of economy made possible by up-to-date plant and methods, and the richness and purity of the ores used.

(11) In the manufacture of steel ingots, the consumption of coal has been reduced to less than 4 cwt.; for blooms from ingots the consumption of coal ranges from practically zero, using soaking pits, up to 3 cwt. for heating, and 2½ to 5 cwt. for raising steam; for rails the consumption of coal ranges from 1 to 3 cwt. for heating, and from 6 to 10 cwt. for rolling, and for plates the consumption ranges from 2 to 4 cwt. for heating and from 8 to 18 cwt. for rolling.

An examination of the figures I have submitted would show that much remains to be done in order to bring down the general practice to the irreducible or even the actual minimum. Taking the case of rails, the consumption from pig iron to the finished rail, is in some cases as low as 11 cwt., and in others it is as much as 23, depending on the character of the conditions. When the hot metal is run direct from the blast furnace into the Bessemer converter, or the open hearth furnace, the consumption of fuel is much less than it would be in cases where the pig iron has to be preheated before being run into the steel furnace.

(12). Considerable fuel economy is likely to occur in the future from the greater use of gas engines, although one recognised authority—Max Meil—stated only a few weeks ago that in his opinion "the economy of gas engines has not yet been demonstrated." This does not apply to gas engines actuated by blast furnace gases, which consume from ¼ to ⅓ of the amount of gas per horse power that is used with steam boilers and good steam engines.

Producer and coke-oven gases have not so far been largely applied to the working of gas engines, because the tar unavoidably retained in the gas causes the valves to stick. There are single blast furnaces in this country producing, say, 240 tons of pig-iron per day, that waste from 15,000 to 17,000 horse power of energy by the continued use of boilers and steam engines. In some cases this extravagance does not matter, as there is no present use for any excess of power, but the fact shows how far our present system is from perfection, and how much we have still to learn.

(13). Much economy of fuel is possible by the use of a more modern type of boiler than the types generally in use, and perhaps this is more especially true of colliery consumption. In one such case brought to my notice lately, using new boilers the evaporation of water per coke oven per hour was 175 lbs., whereas in another case, where the boilers were mostly old and fitted with small flues, the evaporation of water per oven was only 126 lbs., so that the new boilers gave about 40 per cent.

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Mr. J. Stephen Jeans.

17 June 1903.

greater evaporative power than the older ones. These figures, which apply to one firm only, are typical of what is possible in many other cases.

(14). The approximate consumption of coal in the iron and allied industries in 1881 and 1902 is as follows:

Branch of Manufacture.	1881.	1902.
	Tons.	Tons.
Pig Iron	18,011,000	16,500,000
Finished Iron	8,043,000	2,800,000
Bessemer Steel	906,000	1,267,000
Open-hearth Steel	676,000	2,250,000
Crucible Steel	200,000	200,000
Foundry Castings	400,000	670,000
Tin Plates	577,000	500,000
Forgings, etc.	455,000	450,000
Shipbuilding	506,000	875,000
Tubes, Nuts, Bolts, Wire, etc., and Birmingham industries.	3,200,000	3,000,000
Boilers, Engines and Machinery.	7,000,000	8,000,000
	39,974,000	36,512,000

The principal consumers apart from the above are:—

	Tons	Tons.
Railways, approximately	14,000,000	–
Factories	42,000,000	to 44,000,000
Mines	10,000,000	,, 12,000,000
Gas Works	14,000,000	,, 15,000,000
Shipping, Foreign and Coasting.	22,000,000	,, 24,000,000

(15). I have prepared an addendum to that statement which, if you will allow me, I should like to give you, because I consider it somewhat important.

15598. Yes, will you kindly give us that?—Metallurgists look forward to the time when the heat lost in the pig iron and slag in the process of cooling may be utilised. The heat lost in the Cleveland iron district alone has been estimated by Mr. William Whitwell at a figure which would bring it well over 100,000 tons of coal a year. In the slag produced in the same district the heat is estimated at about 200,000 tons of coal on the present output.

The value of the waste gases of the blast furnaces is computed at 1,000 horse-power per 100 tons, giving a surplus of 61,000 horse-power for a make per day of 6,100 tons of iron, equal to a consumption of more than half a million tons of coal per annum, or taking the total pig iron output of the country, nearly three times that figure. It seems probable, therefore, that there may be a good deal of economy possible in the utilising of waste heat at blast furnaces, the total estimated quantity of which has been reckoned at 800,000 tons for the Cleveland district alone, which would represent for the whole country some 2,500,000 tons of coal, if it could all be recovered. This is in addition to any possible further economy in the reduction of the consumption of coke or coal in smelting. Then there is the possibility of reducing the consumption of fuel in finished iron and steel works. If the malleable iron industry were to be wholly superseded by steel, a large economy would naturally follow, and so also if the best heating furnaces were applied in steel works generally.

(16). There are considerable possibilities of the further economy of fuel by the adoption of new methods and conditions of manufacture in the iron and steel trades. Thus, it has been found that a material economy of fuel results from the use of both the Talbot and the Bertrand-Thiel methods of steel manufacture, which promise by-and-by to largely supersede the ordinary open-hearth steel furnace. Some figures given me on this matter show the cost of fuel per 100 tons of steel ingots to work out as under:—

By ordinary process	£27 10 0
,, Bertrand-Thiel	12 10 0
Economy per 100 tons of steel	£15 0 0

If these figures be correct the coal economy possible in the production of 5,000,000 tons of steel, assuming that the whole of our steel output were so produced, should be about £750,000.

15598. That is per year, is it not?—Yes, per annum, assuming that the coal cost 10s. per ton, which is the figure given to me in submitting that statement. In this estimate the quantity of coal used per ton of steel ingots produced by the new process is taken at 5cwt.

(17) Then I have some figures from the recent reports of the American Industrial Commission, which has been sitting for some two years or more, and has been taking evidence on every conceivable subject relating to industry from the best authorities. The figures given here were submitted by Mr. Schwab, who is the president of the United States Steel Corporation, and they practically confirm, as far as they go, the figures which I have already given.

These figures show that it usually requires to make a ton of billets from pig iron

	Lbs.	
Coke	180	
Coal	580	
	760	
Add 30 per cent. to convert coke to terms of coal	54	
TOTAL	814	lbs. or ·36 of a ton.

To reduce the billets to rails, the consumption of fuel is given as:—

	Lbs.
Coke	32
Coal	550
TOTAL	582 lbs.

The two items taken together, represent about 62 per cent. of a ton of coal per ton of rails.

(18). There are 29 establishments in Great Britain that have blast furnaces attached to steel works, out of 140 that make pig iron, so that the cases in which the initial heat of the pig iron can be used in steel melting is only 20 per cent., or one-fifth of the whole.

On the other hand, as there are 92 steel works in Great Britain engaged in the manufacture of steel by the Bessemer or open-hearth processes, there must be 63 (92—29) works that are not carried on in direct connection with blast furnace plants. This means that considerable possibilities of economising the heat in the pig iron are not utilised, as they might be. I have prepared a table which might be interesting, showing exactly the plants in this country that have both kinds of works.

15599. Yes, will you kindly put that in?—Yes. (*The witness handed in the following Table.*)

Pig Iron Works with Steel Works attached in the United Kingdom.

North-east Coast.

Bell Bros.	12
Consett Iron Co.	7
Palmer's Shipbuilding Co.	5
Weardale Coal and Iron Co.	2
N. E. Steel Co.	2
Bolckow Vaughan and Co. (Eston)	3

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South Wales.

Guest, Keen and Co. (including Cyfarthfa)	27
Blaenavon Iron Co.	9
Ebbw Vale Co.	6
Briton Ferry Works	1

West Cumberland District.

C. Cammell and Co.	8
Moss Bay Iron and Steel Co.	4
Barrow Hematite Steel Co.	12
Wigan Coal and Iron Co.	10

Staffordshire—North and South.

Earl of Dudley	4
Sir Alfred Hickman	5
Shelton Iron, Steel and Coal Co.	6

Scotland.

Glasgow Iron and Steel Co.	5
Summerlee and Mossend Co.	7
Glengarnock Iron and Steel Co.	5
Coltness Iron Co.	9

Derbyshire.

Butterley Co.	3
Sheepbridge Coal and Iron Co.	7

South and West Yorkshire.

Leeds Steel Works	3
John Brown and Co.	3
Parkgate Co.	5

Other Districts.

Frodingham Iron and Steel Co.	4
Lilleshall Co.	3
Brymbo Iron and Steel Co.	1

15600. (*Mr. J. S. Dixon.*) Are those blast furnaces?—Yes, blast furnaces.

(19) Then I ought to say that one of the most important subjects which my Board would like me to bring before the Commission to-day, is the subject of railway transport of coal and iron, and I have made one or two notes on the subject which might form the basis of any cross-examination that might be deemed advisable by the members of the Commission. These are as follows: The iron and steel trades are greatly concerned in cheap transport, and they look with much interest and favour on the movement now in progress for adopting larger locomotives and larger wagons. They think that this Commission should, if it can, give encouragement to that movement as a means of enabling the iron trade to command, in reduced rates of freight, a set-off to the higher price of fuel.

I would remind the Commission that while there is no universal agreement as to the suitability of so-called American conditions to British needs, the fact that on the North-Eastern Railway—the pioneer in the movement referred to—the earnings of freight trains increased by 3·2 per cent., while their mileage was reduced by 7·9 per cent., and the receipts per freight train mile have increased by 11·9 per cent., or 18 per cent. within two years, is clear evidence of what is possible in this direction.

15601. (*Mr. Brace.*) Up to what date are those calculations made?—Practically to the present time. These last figures are not my own; they were furnished, I believe, by Mr. Gibb, the General Manager of the North-Eastern Railway Company, to the "Statist" newspaper.

15602. (*Sir George Armytage.*) To the Statistical Society?—I think the figures appear in the "Statist" newspaper; they were furnished by Mr. Gibb to that paper.

Members of the Commission will be familiar with the discussions that have recently been going on in the trade and financial journals of the country as to the possibilities of economy in railway working by the adoption of larger capacity wagons and heavier train loads. I would like to emphasise only one fact, namely, that by the substitution of a 20-ton wagon for a 9-ton wagon there would be a reduction of 35 per cent. in the tare weight of empty wagons hauled one mile, and assuming a train of 13 wagons of 20 tons capacity against one of 19 wagons of 9 tons capacity, there would be an increase in the paying load of a mineral train equal to 44½ tons, or 52 per cent., as calculated in one of the journals that has devoted much attention to this subject.

Mr. J. Stephen Jeans.
17 June 1903.

15603. That is the "Statist" again, I take it?—That, I think, is the "Statist" again, if I remember rightly.

A recent writer in the "Times" has declared that in his opinion, and in that of the leading British railway managers who have been experimenting with American 8-wheel high-capacity wagons, the 20-ton vehicles designed and adopted by the London and North Western Railway, in which the tare is a little over one-third of the carrying capacity, are the most likely to be successful.

Then I have prepared figures indicating the coal traffic to which larger wagons might be applied, the total amounting to 108 millions of tons of coal traffic, including exports, bunkers, the iron trade, gasworks, locomotive coal, etc.

The following figures show the coal traffic to which larger wagons might be directly applied:—

	Tons.
TOTAL quantity exported, say	46,000,000
„ „ bunkers	17,000,000
„ „ iron trade	31,000,000
„ „ gasworks, say half of total, „ or	7,000,000
„ „ locomotive coal, half of total	7,000,000
	108,000,000

There are other branches of the trade in which large capacity wagons may profitably be employed, but these are the more obvious.

As to Possibilities of Transport, I should say that two years ago I went over the Pittsburg and Bessemer Line, and got certain details at Pittsburg showing that on that line, belonging to the Carnegie Steel Company, 156 miles long, the mineral traffic was carried the whole length of the way for 1s. 8d. per ton, or one-eighth of a penny per ton per mile.

15604. The line is 156 miles long; what is the weight of the traffic in the train—what is the train load?—I have not got the train load.

15605. It is rather an important point?—It is an important point; I do not happen to have it with me.

15606. (*Mr. Brace.*) Can you get it?—The net load, to the best of my recollection, is about 2,000 tons; but I have all the figures in my possession. I may say that I have the whole of the figures in that connection, which I obtained from the manager on behalf of the Carnegie Steel Company of the Pittsburg and Bessemer Line. 2,000 tons, I think, is given as the net train load; that, I am sure, is about right.

15607. (*Sir George Armytage.*) As regards this question of larger wagons, how would these suit the sidings and appliances of the iron industry at their works? Are their works laid out so as to enable them to receive these larger wagons?—I should say that in a good many cases they are not.

15608. They would have to be altered?—Yes.

15609. What are they generally laid out for—10-ton wagons?—Usually for 10-ton wagons.

15610. Would the cost of the alterations be large?—There obviously would be a certain amount of cost, but not such a large cost—not generally so great—as would be involved in adapting British collieries for such a change.

15611. But I see your point of view here is that great economy to the railway companies would result from the use of these wagons. Then are you assuming that the railway companies would have sufficiently large loads to make that appreciable?—In the case of traffic intended for iron companies it is a well-known fact, of course, that coal and coke are carried in large loads; in point of fact, a modern blast furnace would consume from 200 to 250 tons of coke per day, and that, of course, would mean heavy and large loads.

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Mr. J. Stephen Jeans.

17 June 1903.

15612. Yes, but would that load all go to the same person?—In the case of blast furnaces and steel works to a large extent that would be so.

15613. Can you give us any instances where railway companies would get very large loads with large wagons going over considerable distances, if they had them?—I do not know that there are many cases at the present time where there are large loads; I do not think there are.

15614. You cannot give us any instances which would justify the carrying out of this suggestion of yours by the railway companies?—In the case of Bolckow, Vaughan, and Company, for example, I know that they have recently adopted a number of wagons of 25 and 30 tons capacity for their iron works traffic.

15615. Where does that go to?—These wagons are used for taking the traffic into the works, and from the works to the shipping port.

15616. How far off?—Not far.

15617. And for their own exclusive traffic?—Yes.

15618. That is not a railway company's question?—It is not.

15619. (*Mr. Bell.*) Is the North-Eastern Railway Company not using these large wagons for transporting coke from the Durham Coalfields to the west?—Yes, they are using considerably larger wagons than formerly; in fact, I had a letter only a week or two ago from Mr. George S. Gibb, the General Manager of the North-Eastern, in which he stated that they had adopted some 5,000 large capacity wagons.

15620. (*Sir George Armytage.*) How large?—25 to 30 tons.

15621. They have built wagons from 25 to 30 tons?—Yes.

15622. What are they using those for?—They are being used for general traffic.

15623. (*Mr. Briggs.*) Are they not nearly all for coal and coke?—Yes, pretty nearly all.

15624. (*Mr. Brace.*) Are they 20-ton wagons, or 20 tons to 30 tons, some 20 and some 30?—They vary between 20 and 30 tons. If I may be allowed, I should like to call attention to another matter. When I was over in Philadelphia about two years ago, I made it my business to see Mr. Ely, who is the locomotive superintendent of the Pennsylvania Railway, and he gave me these figures as representing earnings, expenses, and profits for mineral traffic. These are for the year 1900; average earnings 0·24d.

15625. (*Chairman.*) Per what?—Per ton per mile. Average expenses per ton per mile, 0·17d., and average net profits per ton per mile 0·064d. These, of course, are only submitted, and are only interesting, as showing what has been done and is being done in that district to-day under conditions that are so very different from those which we have in this country. They are not put forward with any idea of comparing like with like; of course, that goes without saying.

15626. (*Sir George Armytage.*) You cannot give us the distances of the train-loads in this case?—Yes, I can. The average length of haul on the Pennsylvania Railway is rather over 100 miles.

15627. (*Chairman.*) You are speaking now of coal?—Yes.

15628. (*Sir George Armytage.*) What is the average gross weight of the loaded train?—Do you mean here or there?

15629. There?—The average is about 550 tons.

15630. Do you mean 550 tons of coal or 550 tons gross?—550 tons of coal.

15631. (*Mr. Brace.*) Then there would have to be added to that the weight of the trucks and the engine, I suppose?—Quite so.

15632. (*Sir George Armytage.*) That is about 27 20 tons trucks?—Yes. I may say that my board, and the members of the iron trade generally, are fully aware of the difficulties that lie in the path both of the railway companies and of the private traders in this matter, and do not wish to press the matter unreasonably; but they still think that a little more enterprise and energy might be thrown into the amelioration, so to speak, of mineral traffic conditions from that point of view; and the recent experience of the North-Eastern Railway Company encourages them to hope that the other railway companies will take steps in the same direction.

15633. (*Mr. Brace.*) Have you not been to America as a member of a Commission recently? I have been reading some correspondence in the "Iron and Coal Trade Review." Is that the result of what you gleaned from experience years ago, or more recently?—Eighteen months ago I was one of a Commission which went over there to inquire into the subjects we have been discussing to-day and kindred subjects, in the interests of the iron trade, and we produced a volume of something like 600 pages, I think, dealing with the whole question of American conditions and competition, including coal and coke, and including railway transport. That book, I think, contains a good deal of information which might be of service to the Commission.

15634. Quite so. What are we to understand with regard to that for the purposes of this Commission? Are you now putting forward in your evidence to-day largely what you gathered there?—Not very much so. It is not quite the same subject.

15635. I agree with you that if we can get that information before the Commission in some way or other, (from what I have read of it, it is extremely interesting) it would be very valuable and important. Whether it bears directly on this subject I am not quite clear, but you yourself would know best?—If the Commission deemed it desirable to get before them the latest conditions of American transport, I certainly think it might be worth while considering the point as to how far they would admit what was contained in that volume into their records, but it is not for me to say what should be done or should not be done.

15636. (*Chairman.*) Do you think that the conditions are such that you could compare like with like?—In my contribution to that volume I distinctly state that the conditions are not identical, and not only not identical, but that they are, in many respects, almost as dissimilar as they could be. The length of haul there, for example, is about 110 miles; the length of haul here is about perhaps 30 miles. I am not aware of any figures (and I think I have looked up the subject pretty well from a statistical point of view) which would give you the average length of haul in this country; but the length of haul for the United States is ascertainable.

15637. Yes, but the real point in comparing the rate per ton per mile, as you have put it, would be rather this, would it not: take two distances which were similar; did you learn whilst you were there what the rate per ton or the rate per ton per mile was for a distance, say, of 15 miles?—Yes, I got certain figures, and those figures unquestionably show that the difference becomes much less material when short distances are considered; that is to say, that their freights become relatively higher.

15638. (*Sir George Armytage.*) To put it shortly, the shorter the haul, the more expensive it is?—That, as you know, sir, is a fundamental rule in all railway transport.

15639. It must be so?—Yes, so much so that it is the cost of handling that forms the greater part of the charge.

15640. (*Chairman.*) Would it be possible for us to get any information bearing upon a point like that from the volume to which you have referred? Would it be too much to ask that we should have the volume and look into it?

15641. (*Secretary.*) It is published, is it not, Mr. Jeans?—Yes, it is published. I should be very glad indeed to let the Commission have the use of a volume.

15642. (*Chairman.*) If you would lend us one for a short time we should be greatly obliged to you?—I will do so with the greatest pleasure.

15643. (*Mr. Bell.*) With regard to this question of large trucks rendering greater facilities to the coal and iron industries, you do not charge the railway companies in this country with any actual shortcomings, I take it?—Well, I do not know about that. If I may be pardoned for speaking about myself, as far back as 1887 I wrote a book under the title of "Railway Problems," in which I urged the British railway companies to do exactly the things they are doing to-day; that was 15 or 16 years ago.

15644. Which things do you refer to?—The provision of large capacity wagons, larger train loads, and larger locomotives; all those things I urged at that time, and I remember when the Railway and

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Canal Traffic Act was under discussion I asked one of the leading railway managers (it is not necessary to mention his name) whether he had ever given any attention to American railway conditions in connection with British railway working, and his reply was that he had never done anything of the kind, that he had never been in the States, and that he knew nothing about American railways. Well, since then, as we all know, most of the great railway companies in this country have sent representatives across to America to study the very conditions that could have been studied to a large extent—not wholly so, perhaps, but to a large extent—in 1887 and 1888. Therefore, my point in regard to that would be that whatever good there may be in these American methods which are so much spoken of and written about to-day, they might have been adopted many years ago.

15645. In view of the difficulties which you appreciate in carrying out these reforms in a very rapid manner—the difficulties which would arise at collieries, for instance, in loading larger trucks, and at shipping ports in unloading them, and in dealing with small trades for which large trucks would not be so very convenient—have you any suggestions to make to the Commission in order to enable them to form any conclusion upon the matter in regard to any recommendations which they might wish to make?—I do not know that I can make any suggestions. The matter, as it appears to me, is before the Commission both in the evidence which they have already heard and in the very great deal that has been written on the subject in various journals, and in the action taken in one or two cases by shareholders. I do not profess to know anything more about these things than my neighbours; it would be presumption on my part to suggest that I know more about what is to help the railway companies than the managers do themselves.

15646. We have had a great deal of evidence given to us setting forth the kind of truck which would be most suitable, for instance, to replace the 10-ton truck. Have you any views as to the size of truck which it would be most useful for the railway companies to adopt, or would you suggest a general transformation?—My view, for what it may be worth, is that a very large part, probably one-half of the total amount of coal traffic in this country, will continue to be carried in wagons of small capacity, probably 10 or 12-ton wagons; but with regard to the remainder, and especially that part of the remainder in which the iron trade is interested, I think that large capacity wagons might almost invariably be employed.

15647. Have you any opinion as to whether the rates charged for the mineral traffic by railway companies are, generally speaking, reasonable and moderate in view of the general circumstances of the cost of carrying?—In view of the general circumstances I would not like to say that they are unreasonable; but, of course, my point of view is that it is possible to economise the cost of transport.

15648. But under the present conditions of transport?—Under the present conditions of transport you have the fact that the railway companies do not pay 4 per cent. dividend. You could hardly say that a railway company which was not paying 4 per cent. over the whole was making exorbitant profits. I think that is the answer to the question as to whether the rates are reasonable or not.

15649. (*Chairman.*) But I gather what you wish to impress, and, if I may say so, very rightly, is that if there is any plan either for the railway company or for anybody else to reduce the cost and to economise, it is very desirable that that should be done?—Exactly so, my Lord, and not only that, but I think that the railway companies, when they have found out that method, and when they have realised the economy that is possible, or believed to be possible, should share it with the large traders.

15650. (*Mr. Bell.*) You say that "producer and coke oven gases have not so far been largely applied to the working of gas engines." We had some evidence yesterday to the effect that gas engines are being run by blast furnace gas?—I do not mean blast furnace gases, but producer and coke oven gases; that is a separate kind of gas.

15651. We were told that gas engines for generating power have for some time been successfully used at the Sheepbridge Ironworks?—That is blast furnace gas; that is not the same.

15652. (*Chairman.*) But there is no difficulty about producer gas, is there?—Well, there have been many attempts made to utilise it, and I am afraid a number have not been successful. I am not here to say that producer gases have never been successfully used at all, but there has been a good deal of difficulty about them.

15653. At any rate, I saw it stated in the paper the other day—and everything that appears in the papers must have some foundation—that the Midland Company had entered into a contract with the Westinghouse Company, by which all the electric power and the other power to be produced at Heysham was to be provided by means of gas engines. That would be what you call producer gas, would it not?—It might be blast furnace gases.

15654. At Heysham?—I think there is no doubt about blast furnace gases; and those of us who are interested in the subject look forward to a very large development of the use of blast furnace gas for gas engine purposes The movement is making very rapid progress to-day.

15655. (*Mr. Bell.*) When you speak about coking coal, you say something with regard to the desirability of ceasing to export coking coal. Do you wish to go as far as to suggest to the Commission that they should recommend that?—That is a matter for consideration, and it is one of the reasons why my Association took action in the matter at all. The quantity of coal in this country available for the manufacture of coke, and especially of good coke, is believed to be very limited. That no doubt is a question into which this Commission will inquire, and which I take to be one of the reasons for its appointment. At any rate, I may say that that was one question that the Iron Trade Association had in view in wishing to have such a Commission appointed; but if it be the fact, as we believe, that the quantity of coal available for the manufacture of coke is limited (and in some cases very limited), it then becomes a question of policy as to whether it would be better to retain what we have for the manufacture of iron, whereby we should be able to employ a large amount of labour; or whether it should be exported, in which case there is no labour employed, and many interests would be likely to suffer, not immediately perhaps, but in the long run.

15656. And that really very important and serious recommendation comes with all the force of this great and powerful institution—the British Iron Trade Association?—As a subject to be inquired into.

15657. (*Sir George Armytage.*) But are we to understand that you are requested by your Association to say that in their opinion no more coking coal or coke ought to be exported?—No, but I am authorised to say that in the opinion of my Association that is a subject to be inquired into. The question of the desirability or undesirability of retaining the limited supply of coking coal that we have in this country for iron trade purposes is one which it is very important to us to have examined.

15658. But they have not formed an opinion themselves on the subject?—Well, some of them have doubts as to how far it is a desirable thing.

15659. (*Chairman.*) They have no doubts as to how far it is a practicable thing?—That, I take it, would be a matter for the Commission to inquire into. Of course we are interested in having the cheapest coke we can get, and in having the supply continued as long as possible.

15660. (*Mr. Young.*) You are speaking now as consumers?—Yes.

15661. (*Mr. Bell.*) You are speaking of the best quality of coke. I think we have it in evidence that you do not necessarily require the best coking coal, such as is used in Beehive ovens, for instance, to produce an excellent coke in the bye-product and retort ovens. Have you any information as to that, and as to the quality of coke, and the appreciation of the coke made in those retort ovens?—I can only say that in one or two cases which I know of here, entirely satisfactory coke has been made in retort ovens, and in Germany where the bye-product oven system has been mainly developed, as you know, probably three-fourths, if not more, of all the coke ovens in operation are these bye-product ovens, making, so far as one has the opportunity of knowing, a very satisfactory quality of coke.

15662. Yes, we have it in evidence, I think, that on the banks of the Tees, for instance—confining our attention paticularly to our own country, where you suggest

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Mr. J. Stephen Jeans.

17 June 1903.

we should keep our own coal—it is not necessary to have this best coking coal in order to make coke in these retort ovens; but even common slack is being imported into Middlesbrough from Yorkshire, and is being mixed with Durham coal for the purpose of being converted into coke in these retort ovens, and a quality of coke is being made, which at first was considered to be, partly on account of its appearance, of very inferior quality, but is now admitted to be very good; and some people consider it to be even better and more solid, and to give more blast than what is commonly known as coke from the best coking coal. What is your opinion of that?—I think that quite confirms what one hears of the coke made in the German ovens.

15663. And that would not point to the necessity of keeping any particular part of the coking coal?—You must have a particular sort of coal in order to be able to make coke at all.

15664. That would apply to nearly the whole of the Durham coalfield, would it not?—Well, the South Durham coalfield is mainly coking coal; I do not know much about North Durham; but Sir Lindsay Wood is present, and he knows it much better than I do.

15665. You would call a gas coal coking coal, would you not?—Well, it is not the coal that is usually employed for smelting purposes.

15666. (*Chairman.*) Would you prohibit the export of pig iron?—Well, that is a subject as to which I must start at once by saying that our Board, as a Board, has never considered it; but if you ask my own individual opinion, I say it is rather a pity that we export relatively so much pig iron as we do.

15667. Quite so; but I see no difference in principle between the one and the other?—In other words, I think it would be better if the whole of the pig iron that we exported were worked up in this country into finished articles, and exported as finished manufactures.

15668. (*Mr. Bell.*) Generally speaking, you would advocate keeping all these raw materials at home for our own purposes?—Well, that, of course, would depend upon the conditions entirely. You could not keep pig iron at home. If you attempted to keep pig iron at home you would lose a very large part of the export trade, because there are nations, such as Germany, which want mainly pig iron from us if they take anything at all.

15669. (*Mr. Young.*) Would you not in that case, seeing that you think it is a pity that we export so much, refuse to send it over to Germany, and advise people here to manufacture it?—Well, people here would manufacture it if they could get a market for the finished product. It is entirely a question of the extent of the market that you can command for a finished product.

15670. Then if you cannot get a market for the finished product, why is it a pity that we send it out instead of manufacturing it?—I do not say it is a pity that we send it out. I say it is a pity that we cannot get the same volume sent out in the form of finished articles; because by sending it out as pig iron we are supplying other nations with the raw materials for manufacturing finished goods with which they compete against us in other markets.

15671. Then, under present conditions existing in other countries and in this country, it is better to send it where you have a market?—We must do so—we cannot help ourselves.

15672. (*Mr. Sopwith.*) There is a question which I wanted to ask which is rather on the same lines as what Mr. Bell has put with regard to coke. You speak also about there being a threatened scarcity of cheap coal in several districts. Of course, that is a very important question with regard to the resources; but to take an individual case, there is South Staffordshire. Is there any real evidence as to the iron industry being threatened by the absence of cheap coal in Staffordshire—apart from the question of the wages or cost of production on account of the exhaustion of the well known standard seam?—I have not the figures by me, but my recollection is that it has been assumed for quite a long time that the Staffordshire coal would be among the first to give out.

15673. Are you taking any special seam into consideration?—Of course the 10 yard seam is already exhausted over a large area.

15674. Yes, but then it has been developed in other areas?—Yes, in a few cases that were not known of a few years ago.

15675. We are perfectly aware of the fact that the question is affected by proximity to the seaboard?—Yes.

15676. You said that much economy of fuel is possible by the use of a more modern type of boiler. Of course, that goes without saying generally, but would you give your views as to what that means; do you mean that a Lancashire boiler with 100 lbs. pressure, or whatever it may be, would be a standard?—I would rather not do that, because I do not come here as a boiler expert.

15677. Then, with regard to the question of wagons, you put it particularly, I gather, that about half the output of the kingdom could be conveyed conveniently and suitably and economically in large capacity wagons?—That is my view of the matter.

15678. (*Mr. Briggs.*) You said that if the coal was exported there was no labour on it, whereas in the case of the iron it was kept at home to make pig iron, thus causing expenditure of labour in the country. Could you tell me about what the modern cost of labour on a ton of pig iron is now?—Do you mean in this country?

15679. Yes?—There are cases where the cost of the labour at the furnaces per ton of pig iron is as low as 2s. In other cases it is 4s. or more.

15680. Still, in modern practice it is reduced to about 2s.?—Yes; in the best practice.

15681. Then I think we might take it that the labour on the coal is not less on the average than 5s. per ton, that is to say, the labour in raising the coal?—That is a point I could not undertake to answer. My recollection is that some years ago (since which time, of course, the conditions have changed a good deal) in the Durham coalfield the labour per ton of coal raised was not more than 3s. 6d. I put that figure forward with reserve; it is a recollection and it may be imperfect.

15682. I think it is a correct recollection, but still I think you may take it now that the cost is nearer 5s. There are about two tons of coal to one ton of pig iron, are there not?—Yes.

15683. So that there is 10s. per ton paid in labour on the coal, even if it is exported, as compared with 2s. on the pig iron?—That would appear to be so.

15684. There are other working men who are paid on the coal output, and if you restrict the output of the coal, a much heavier labour bill would, in fact, be stopped, would it not, supposing you prevented the output of that coal, unless you could use it for pig iron?—Yes, of course, there is the assumption that if you produce the pig iron you work up the pig iron afterwards into steel and other products, employing a very large amount of labour.

15685. Yes, but the Chairman, very properly I thought, asked you a question on that point; would you also prohibit the export of pig iron, because if you begin with the export of coal, you must follow it up with the export of pig iron, or else you would not get the full advantage of the labour which you very naturally wish to keep in the country?—Of course, I may say that although that suggestion has appeared in my statement, I do not put it forward as fundamental in any sense.

15686. Is it not really the fact that probably the tariffs on the more finished productions abroad are drawn exactly in order to prevent our doing that?—That is possible.

15687. (*Mr. J. S. Dixon.*) You have given us a history of the continual economy in coal consumption since 1881 in the manufacture of iron and steel. I suppose it applies to other articles of commerce as well as to these?—I should say that in all great industries where power is employed, there has been within the last 20 years a very notable economy of fuel.

15688. I do not know whether you can give us any information on what I am going to ask you in following that up, namely, that notwithstanding that the output and consumption of coal generally has increased, do you think that will go on? We are asked here to estimate how long our coal is likely to last, and I want to get your opinion on the subject?—That might very largely depend (and some of us think it will largely depend) upon the fiscal policy adopted in the country.

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15689. But will not a time arrive when these economies will overtake and diminish the consumption?—That, of course, is a likely enough thing to happen.

15690. You mentioned, also, that someone has estimated an increase of 20,000,000 tons per annum of pig iron during the next 10 years, and you gave us certain sources from which ores might be got. Do you think it is possible that those should be produced from these districts?—Well, every day we are getting information of further sources of ore supply, but we are not in a position to say much about them—our knowledge is very imperfect. I may not be saying anything out of place if I state here that only yesterday the Board of my Association resolved to take steps to get the British Consuls throughout the world, instructed by the Foreign Office, to make special reports on the subject of iron ore supplies, so that the whole thing might be before us.

15691. You are aware that there is any quantity of argillaceous, or what we call clay-band ironstone, in existence in this country?—Well, you do not use much of it in Scotland to-day.

15692. No, I say there is plenty of it; it is not for want of it, but it is a question of being able to work it profitably?—Well, of course unless you get your cost down to a certain figure you cannot manufacture at all.

15693. Then with regard to this question of Durham coke becoming scarce, there are very large quantities of South Yorkshire coal used for making coke, especially with the new systems of compression in bye-product ovens?—Yes, that is true.

15694. Then does not that meet your difficulty and obviate the necessity of trying to limit the output?—It is a question of the cost of transport. You cannot make use of Yorkshire coal economically in a Cleveland blast furnace, because you have to carry it so far.

15695. I am not aware whether there are any other coals in Durham which are suitable for coke-making under this system. The gas coals are produced there extensively?—They have their own sphere, of course.

15696. But could not that be supplied if the Cleveland iron furnaces had improved processes of manipulation?—Supposing that were possible, you would deplete the available resources of gas coal, which, I take it, are not over-abundant.

15697. You point out that 130 years hence (which is a good long time) the Durham coal will be exhausted, and you indicate that we should prevent the exportation of that coal. Is there not a strong probability that the supply will be made up from some of the sources which I have indicated?—I hope it may be so. Of course in other fields the coking coal will probably not be so near exhaustion by a long way, but in other fields I think I am right in saying that the coal does not make so good a coke.

15698. I do not suppose it does. Durham coal is the king of coking coals, I know that; but the same thing applies to America; they are working out their best coals there, are they not?—That is true, to such an extent that the Connellsville coal region, which supplies the great bulk of their coke supplies, is estimated not to last more than another 25 years.

15699. So that at the end of that time Durham will have rather the advantage of them?—Durham will be rather likely to outlast Connellsville, if this estimate be true. I did not make the estimate.

15700. My point is that there is no such immediate cause for alarm as your Association seem to imagine, or as you seem to imagine?—Well, if your coke does not last you more than 30 or 40 years——

15701. You said 130?—130 was the estimate I made in 1877.

15702. The output has not gone up very considerably?—Not very materially. It may have gone up about 1,000,000 tons per annum since then.

15703. Does this Talbot system of steel-making tend to further economise the coal consumption?—Yes, they claim to effect a very notable economy.

15704. You described the loss of heat by the cooling of the pig iron and slag at the works, which is a very considerable amount. Is there any immediate prospect of that being utilised?—I am afraid not. As a theoretical matter it has been to a certain extent experimented with, but as a practical source of economy I do not attach much importance to it.

Mr. J. Stephen Jeans.

17 June 1903.

15705. Our object, as you are aware, is to ascertain what economies are likely to be brought about with a view to curtailing the consumption of the coal resources and conserving them, and that is the reason why I ask you these questions?—Quite so.

15706. (*Dr. Le Neve Foster.*) Coming back to this question with regard to the probable shortage of coke in Durham, are there any seams in Durham with too much ash, we will say, at the present time to be available, but which might be made available for coking purposes if you washed the coal?—Unquestionably.

15707. Would not that allay your fears to a certain extent?—Yes; if washing were more generally adopted I think that would to a certain extent meet the case.

15708. You say "Our coke manufacturers have hitherto been afraid that bye-product ovens would injuriously affect the quality of the coke, but that is not now a matter for such anxiety as it was." Is it really a matter for any anxiety?—Well, one can infer that, rather than base it upon any definite knowledge of the general sentiment. As a matter of fact, the number of bye-product ovens adopted in this country up to quite a recent date was very small, as you may know, and the bulk of the plants have been constructed, I should say, within the last three years—those that are actually in operation to-day. I am speaking off the book, and this is a mere guess, but I should say that three-fourths of the coke ovens in this country to-day are the old-fashioned Beehive ovens. Of course, the inference is that these bye-product ovens, whereby the cost of coke is materially reduced, have only failed to make rapid progress (such progress as they have made in Germany) by reason of the apprehension that the coke was not all that was wanted for blast furnace purposes; but I can go further than that, and say that I know of cases where pig-iron smelters have refused to have anything to do with bye-product ovens.

15709. Is it not a fact that where the blast furnace owner is also proprietor of bye-product ovens he tells you that the coke he is making for the bye-product oven is every bit as good for his purposes as the coke made in the old Beehive oven?—That is what I should state—that those who now use bye-product coke made by the most up-to-date methods, and the most up-to-date ovens, appear to be satisfied with it.

15710. But is it not a convenient thing for the purchaser of bye-product coke to say that he is apprehensive in order to get that coke at a rather cheaper rate?—That is an ordinary commercial consideration.

15711. (*Mr. Young.*) Do you appear here on behalf of the iron trades, and with regard to the recommendation which you are making for the restriction or modification of the exportation of coke or coking coal, do you speak on behalf of your Association simply as consumers, or from a national point of view?—Well, in so far as your suggestion has any significance at all, it is only, of course, in relation to the consumption of coke by the pig-iron trade that I speak. The necessities of our own industry would seem to render the export of coking coal or coke, as such, very undesirable.

15712. Supposing the exportation of coking coal were stopped altogether, how much longer would it remain available for you to smelt iron?—That is a question I have not studied.

15713. Can you say approximately?—As a matter of fact, the exports of coking coal from this country are relatively small.

15714. The exports of what coal? Do you mean that the exports of coking coal are relatively small?—Yes I speak of coking coal. They tend to increase, of course.

15715. And if it was totally stopped, do you think it would last as long again as it will if it is continued to be exported?—Oh, dear, no; the difference would not be really very material on the present annual export of coke or coking coal. But some years ago a good deal of coking coal was exported to Germany from the north of England, and the Germans converted that into bye-product coke and sent back to this country a certain quantity of coke so manufactured—not very much—and they sent over here also a good deal of iron and steel that was made from the coke so manufactured.

15716. If it was profitable then to the producers of

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Mr. J. Stephen Jeans.

17 June 1903.

that coking coal to send it over to Germany, and profitable again to purchase that coke back, was it not better to do that than simply to keep it here, without, we will say, our people in this country adopting the same means that they had already adopted in Germany? —Well, that is a fair subject for discussion. I should think that there would be more or less difference of opinion on the subject. I do not know that I could answer the question offhand.

15717. If, then, by stopping the export of this coking coal you throw a very large number of hands out of employment here, do you think that that would be an advantage over continuing to export it?—Such a case could hardly occur, because the total quantity of coke exported up to the present time has been relatively very small, as I said before.

15718. Then, if it is relatively small, is it a serious matter to continue exporting it when it is an advantage to the people producing it to do so?—Well, we do not put it forward as a very serious matter; we only put it forward incidentally.

15719. And the Association that you are representing here does not attach much importance to it?—We do not come here putting that forward as any fundamental part of our case at all.

15720. I think in the early part of your evidence you referred to some great increase that had taken place, either in the quantity of tonnage carried over the North-Eastern line or in the earnings in 1902, as compared with the previous years. I think you said there had been an increase of 11 per cent. in tonnage in 1900 over the previous year and of 18 per cent. over the two years as compared with the preceding year?—Yes.

15721. And that, I think, you inferred was entirely due to the larger wagons which had been introduced? —I do not say that. I say there is no universal agreement as to the suitability of so-called American conditions to British needs; and then I go on to add that these facts which you have just named give an indication of what is possible by the general application of the American railway conditions in question to the great trunk lines of this country—not wagons alone, but wagons plus larger locomotives, heavier train loads and other matters.

15722. Can you give the proportion or the tonnage of the large wagons that had been put on duty in 1902 compared with 1901?—In this country?

15723. Yes—No.

15724. On the North-Eastern line?—There were 5,000, I think.

15725. What proportion of the total tonnage on that line?—I could not say off-hand. I could get the figure if you are interested in having it.

(*Mr. Bell.*) It would be very interesting.

15726. (*Chairman.*) You will be good enough to let us have the volume which has been referred to?—I shall be very pleased to do so.

15727. (*Mr. Bell.*) Would the witness let us have this information? It would be rather interesting to know the percentage that these large 5,000 wagons bear to the total number of mineral trucks on the North-Eastern Railway.

(*Mr. Young.*) To the total tonnage?

(*Mr. Bell.*) Yes.

(*Chairman.*) Do you mean the total capacity tonnage?

(*Mr. Bell.*) Yes—I will endeavour to ascertain it, and send it to the Secretary.

15728. (*Mr. Briggs.*) I do not see how there can be any means of knowing what the North-Eastern Railway tonnage is, because they run lots of wagons belonging to traders in the district?—I can only, of course, write to the general manager of the company and ask for the figures; I could do no more than that.

15729. (*Chairman.*) No, but Mr. Briggs points out the difficulty in those cases. In fact, I should doubt very much whether the North-Eastern Railway Company could supply the information. You could, of course, without any difficulty ascertain what proportion the large wagons bear to the smaller wagons belonging to the North-Eastern Railway Company?—Yes

(*Chairman.*) But when you come to estimate as to what is the proportion of tonnage carried in the large wagons compared with the total tonnage carried by the North-Eastern Railway Company, I suppose you could not get that from them?

(*Mr. Briggs.*) You could not get the size of the wagons in which it is carried?

(*Chairman.*) Quite so.

(*Witness.*) One could only write to the general manager.

(*Mr. Bell.*) I think it would be quite sufficient if we could get to know the relative quantity of large capacity trucks owned by the North-Eastern.

(*Chairman.*) That would do; there would be no difficulty about that, I should think.

15730. (*Mr. Bell.*) It is the carrying capacity we want?—I have made a note of that.

TWENTY-SEVENTH DAY.

Thursday, 18th June, 1903.

PRESENT:

THE CHAIRMAN.

Sir GEORGE ARMYTAGE.
Sir WILLIAM LEWIS.
Mr. BELL.
Mr. BRACE.
Professor DIXON.
Mr. J. S. DIXON.
Dr. LE NEVE FOSTER.
Professor HULL.
Mr. MACLAY.
Mr. SOPWITH.
Mr. TEALL.
Mr. YOUNG.

THE SECRETARY.
THE ASSISTANT SECRETARY.

Mr. JOHN ROBERTS, called; and Examined.

Mr. John Roberts.

18 June 1903.

15731. (*Chairman.*) You are a Mining Engineer?—Yes, I am a Mining Engineer in practice at Swansea, and have had 28 years' active experience in working coal under various conditions in the Western Division of the South Wales Coalfield. I am an Associate Member of the Institute of Civil Engineers, a Fellow of the Geological Society, and one of the Examiners for granting certificates of competency under the Mines Regulation Acts for the South Wales District. I am Consulting Engineer to several of the largest mineral estates and collieries in the district referred to. I have had extensive experience in letting minerals, and am acquainted with the covenants usually existing between lessor and lessee. I am also well informed as to the geological

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characteristics of the country. I propose to speak of the Western Division of the South Wales Coalfield.

15732. You refer in one part of your evidence to a map?—The field contains bituminous, semi-bituminous (or steam), and anthracite coals of various degrees of quality and hardness. I produce a map showing the portion of the coalfield referred to, sub-divided as follows:

Supplement plates 21 and 22.

Area No. 1 containing bituminous coal - - - - - - -	Coloured green.
Area No. 2 containing semi-bituminous coal - - - - -	„ yellow.
Area No. 3 containing semi-bituminous coal in the upper seams and anthracite coal in the lower	„ pink.
Area No. 4 containing anthracite coal in all the seams - - -	„ blue.

There are no newer geological formations covering the coal measures except glacial drift and alluvial deposits, so that for all practical purposes the outcrops appear at the surface.

15733. You say that area No. 4 contains anthracite coal in all the seams. Does that mean that in the area coloured blue there is nothing but anthracite, or does it mean that in all the seams in the area coloured blue there is anthracite?—It means there is nothing in the area coloured blue but anthracite.

There are no strata of an exceptional character to sink through, except the Pennant and Cockshot rocks. I also produce a general section extending across the coalfield from north to south, from Garnant to Swansea, but having regard to the limited information available, it is difficult as yet to correlate with any degree of accuracy the seams outcropping on the south with those occurring on the north side of the field.

Supplement plate 23.

The section will therefore show the seams in the positions in which they have been proved at their respective outcrops from actual data; while the position given to the strata in the middle of the field is necessarily hypothetical. (The section is prepared on the assumption that the seams will exist to the dip as on the outcrop, but where the thinning out occurs can only be proved hereafter. Where the thinning out from 34 seams to 18 and from 83ft. to 47ft. occurs is a problem difficult to solve, but one which will have an important bearing when the quantities of available coal in the field are being calculated.) The number of the seams, their general characteristics, as well as the thickness of the strata intervening between them, vary so much, that no two sections taken more than five miles apart would be exactly alike.

The strata dip from south to north, then flatten into a synclinal basin, and subsequently rise northwards. On the south outcrop the dip is at the rate of 18in. to the yard. There are, however, local exceptions where for considerable distances it assumes an angle of 45° and even 50°. It is only in a few of the upper seams that workings have extended from outcrop to outcrop across the synclinal basin. Taking one of these seams as an example, the dip on the south side would be at the rate of 18in. to the yard for 600 yards (measuring along the line of dip). It then flattens out until it reaches the southern end of the basin at 3,000 yards. The basin is approximately level for 1,400 yards, when a northerly rise commences and continues to the outcrop at an inclination varying from 4in. to 8in. in the yard. This typical case is only applicable to one of the uppermost seams, and must not be taken as representing the whole. The next lowest seams obviously possess a longer distance from crop to crop, increasing with each seam in descending order.

The strata thicken out from north to south, and the number of workable seams increases in a corresponding direction. On the north side the strata are estimated to measure 1,600 yards thick, and contain 18 seams, giving 47ft. of workable coal. On the south crop the thickness of strata is 2,150 yards, containing 34 seams, giving 83ft of workable coal. These dimensions are computed from the lowest workable seam upwards. The measures are usually divided into three series viz.:—

(1) Upper Pennant Measures - -	800 yards thick.
(2) Lower Pennant Measures - -	600 yards thick.
(3) Lower or Ironstone Measures -	750 yards thick.

These distances are measured on the south outcrop. It is obvious that they would be less towards the north.

The quality of the coal changes from highly bituminous on the south outcrop to semi-bituminous (locally termed "steam coal") in the synclinal basin, and anthracite from the syncline northward. The bituminous area contains coal giving by analysis from 30 per cent. to 18 per cent. of volatile matter; the steam coal area 18 per cent. to 11 per cent., and the anthracite area 11 per cent. to 4·25 per cent.; but in Pembrokeshire a coal containing a still less percentage of volatile matter is being worked.

It is impossible to fix a geographical boundary to the southern edge of the anthracite field, since its position must necessarily depend upon the point where the quality of the coal blends into semi-bituminous, gnd for similar reasons the extent of the semi-bituminous or steam coal area will be decided by the point where its quality becomes bituminous. Where, however, pits have been sunk in the steam coal area, a constant feature attending each of the seams intersected is the fact that the higher seams contain the largest quantity of volatile products. In other words, the seams gradually get more "dry" in descending order. This rule applies with equal certainty to the eastern division of the coalfield. In illustration of this fact the following table is the result of an analysis of three seams proved in the same vertical plane in a pit sunk on the Upper Pennant series.

No. 1 seam at 52 yards (allow me to put myself right; it is not necessarily the No. 1 Rhondda, as the seam is commonly known).

15734. (*Sir William Lewis.*) What pit is that?—Gorseinon.

15735. That is not along this section?—No.

No. 1 seam at 52 yards deep contained 17 per cent. of volatile hydrocarbons; No. 2 seam at 200 yards deep contained 14·7 per cent. ditto; No. 3 seam at 334 yards deep contained 12·1 per cent. ditto.

The first seam is a bituminous steam coal; the next is steam coal of high quality; the third a "dry" steam coal. The depth from No. 3 seam to the lowest in the Pennant series would be 335 yards. The depth to the lowest seam in the coalfield would be 1,689 yards below No. 3 seam.

15736. At Gorseinon?—Yes, below that No. 3.

15737. (*Chairman.*) Those measurements would apply if the pit were sunk to the lower depth?—If the existing pit were sunk to the lower depth.

Where workings have extended in the more inclined seams from the outcrops towards the dip there is always a falling off in the quantity of bitumen as the dip is approached. Samples taken in the same seam at the outcrop and at a point 1,450 yards to the dip showed a a difference of 15 per cent. in favour of the former. I have been unable to tabulate a formula that will correctly state this loss, but, speaking generally, I would say that in the more bituminous area the loss is at the rate of 1 per cent. of volatile hydrocarbons for every 100 yards measured along the line of dip. There is, however, no hard and fast rule applicable to the case, since no two seams are exactly alike in quality.

Morover, the formula will not hold good for all distances, the loss being considerably less where the coal has been low in bitumen or "dry." In other words, while the change from "bituminous" to "steam coal" occurs within a comparatively short distance, the change from "steam coal" to "anthracite" is of a much slower character, and extends over a considerably longer distance measured along the plane of the seam.

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Mr. John Roberts.

18 June 1903.

Bringing my experience to bear upon the subject, I give the following as the nearest estimate I can make of the area occupied by each kind of coal :—

	Square Miles.
No. 1 Area in which all the seams are likely to be bituminous, varying in quality from 35 per cent. to 18 per cent. of volatile matter	94
No. 2 Area in which the seams are likely to be semi-bituminous (but in many parts anthracite), and varying in volatile matter from 18 per cent. to 10 per cent.	61
No. 3 Area in which anthracite exists in the lower seams and semi-bituminous in the upper; semi-bituminous, varying from 10 per cent. to 7 per cent., and anthracite from 7 per cent. to 4·2 per cent. of volatile matter	77
No. 4 Area in which anthracite exists in all the seams	133
Total area of the part dealt with	365

15738. Does that represent the field which is marked on this map with the respective colours?—Yes, with the respective colours.

I further estimate that of the foregoing area, the coal under 253 square miles will be found at a depth not exceeding 3,000ft., while the remaining 112 miles will be below 3,000ft. from the surface. The depth to the lowest workable seam in one locality will probably reach 6,000ft., and it is not improbable that the anthracite area will extend beyond the limits shown on the map.

In bringing to the notice of the Commission the situation, areas, and qualities of the different coals, I desire to call attention to the comparatively small area of high quality steam coal available, as well as to the circumstances under which it exists, as regards depth and other conditions. The whole of it can only be successfully won by shafts sunk entirely through the Upper and Lower Pennant Measures, with their respective sandstones. Having regard to the important manufacturing industries existing in the locality under consideration—increasing in number year by year—and to the large population dependent upon them, I also desire to call attention to the conditions under which the area of bituminous or manufacturing coal exists. I may also point out the large reserves of anthracite coal that are available.

15739. Are you going on now to explain what you mean when you say "I also desire to call attention to the conditions under which the area of bituminous or manufacturing coal exists"?—If it is your pleasure.

15740. Let me see if you quite understand what I mean. You have called attention to the conditions in the previous paragraphs, and you explained what the conditions were, and you went on to say, "the whole of it can only be successfully won by shafts sunk entirely through the Upper and Lower Pennant Measures with their respective sandstones"?—The same will apply to a lesser extent as regards the bituminous coal; but what I particularly wished to call attention to was the depth at which the bituminous would have to be followed, and the conditions of existing workings along the outcrops. I shall make reference to it in something I say later on.

15741. That answers me.

As to faults and dislocations: The faults that occur within the area under consideration intersect the coalfield chiefly in the direction of north-west and south-east (probably caused by what is termed the Charnian movement). The more important of them are 28 in number, having a displacement varying from 28 yards to between 400 and 300 yards; 19 are dipping west, 7 dipping east. These faults almost invariably affect all the seams, and are likely to cause a considerable loss of coal. There are instances where the seams in close proximity to a fault are deteriorated both as regards hardness and quality, while there are others where the coal next to the faults occurs in the healthiest possible condition.

There are several east and west dislocations (Armorican), which have tilted up the strata in the bituminous area, while in the north or anthracite division there are several important south-westerly disturbances (Caledonian), resulting in the strata, with their accompanying seams of coal, being tilted up on end, or folded into a series of minor anticlines, synclines, and overlaps. These dislocations appear chiefly to affect the lower series of seams only. There are a few local "wash-outs," or areas of barren ground, but they are unimportant—unimportant in relation to the whole area of the field, I mean. There are frequently minor disturbances in the shape of small faults, folds, overlaps, and "change of leaf." The reports of the Geological Survey have thrown considerable light upon this question, and colliery owners and their managers, as well as the general public, are now more fully equipped with information as to the situation, nature, and effect of these faults and disturbances.

As a general rule, I would say that the effect of these faults and dislocations upon the economical working of the coalfield is chiefly in the increased cost of getting and in the larger yield of an unmarketable product in the shape of soft coal and culm, which, however, in some cases must be worked, thereby adding to the cost of production, and to the quantity of small coal gobbed in the workings. By soft coal I mean coal that cannot be produced in the ordinary way as "round" coal, and which is therefore in that respect less valuable as a marketable product. By culm I mean the anthracite small coal sent out with the large and screened over a 1¼in. screen or gobbed in the workings where necessary or desirable.

THE ANTHRACITE AREA.

In using the term anthracite, I refer to coal containing 88 per cent. and upwards of fixed carbon. The whole of the seams existing in this area form the north-west outcrop of the coalfield, and as there is no overlying strata, they practically come up to the surface. Their past development has in consequence been fairly easy and without the necessity of sinking deep pits. The collieries are chiefly of a small character, and the number at present at work is as follows :—

Yielding an output of 1,000 tons a day	1
" " 500 tons and under 1,000 tons	5
" " 250 tons and under 500 tons	13
" " under 250 tons	47
Total Number	66

The total output during the past year was about 2,600,000 tons.

The following table showing the yearly output since 1887, appears in the report of H.M. Inspector of Mines issued in 1903 :—

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Year.	Total Output, Tons.	Annual Increase, Tons.	Annual Increase per cent. on Previous Year.
	Tons.	Tons.	Per Cent.
1888	906,258	—	-
1890	1,220,916	314,658	34·72
1891	1,258,161	37,245	3·05
1892	1,309,701	51,540	4·09
1893	1,262,934 (decrease).	46,767 (decrease).	3·57
1894	1,550,154	287,220	22·88
1895	1,761,186	211,032	13·61
1896	1,784,963	23,777	1·35
1897	1,830,600	45,637	2·55
1898	1,805,490 (decrease.)	25,110 (decrease).	1·37
1899	2,113,720	308,230	17·07
1900	2,204,468	89,748	4·24
1901	2,254,066	50,598	2·29
1902	2,596,665	342,599	15·20

15742. That shows the increase for each year?—Yes; the increase from 1887 to 1902 is 287 per cent.

This increased production has followed a general increase in the number of uses to which anthracite is being applied, and is perhaps also due to a greater readiness on the part of colliery owners to assort the output into the various sizes required by consumers. A large number of collieries are now provided with screening and assorting plants, and in some instances washeries.

The method usually adopted in working this part of the field is to open out in the seam by "slope drifts," or engine planes, driven in the direction of the dip, and continued in the seam itself, where level headings are turned to right and left in the strike of the measures. From these, cross headings are turned off to the rise of the dip, as occasion may require, and working places opened out therefrom. Cross-measure drifts are sometimes driven to intersect overlying and underlying seams, the coal being brought out to central stations and conveyed to the surface through each main engine plane. These planes are worked to various depths, 800 and 1,000 yards (measuring along the dip) being of common occurrence. There are instances where they have reached 2,100 yards from the outcrop. This mode of working is that which has best lent itself to the circumstances up to the present; and although there are 66 anthracite collieries in actual operation, only 8 of them are pits, the remainder being engine planes, as above described.

15743. Would you say as to the eight that they are pits because the seams are deeper?—No; the workings have extended considerably below the pits, and I think the deepest pit is about 230 to 240 yards. I am open to correction there, but so far as my memory serves me it is from 230 to 240 yards.

The system of getting the coal varies with the nature of the roof, the dip of the strata, and the general circumstances attending each case, but that most commonly in use is the "long-wall." There are a few instances of pillar and stall (single and double road stalls) at work. The yield of small in pillar and stall workings is necessarily greater owing to the additional number of side cuts.

The coal is worked as "large" and "small," the collier filling out the coal as nominal large and gobbing part of the small (or "culm") into the workings. The exceptions to this rule are, where by the nature of the strata soft and inferior coal occurs, or where main roadways and airways and narrow places are driven. In those cases the coal is all sent out as "through and through." The collier is paid a higher price for "large" than for "through and through," varying from 3½d. to 7d. per ton (standard). This is in consideration of the small that is sent out and thrown to the gob.

The seams vary in thickness from 2ft. 4in. to 13ft. There are instances of seams less than 2ft. thick being worked, but only in periods of good trade, and when the circumstances are exceptionally favourable to economical working. One seam, locally known as the "18 feet," has a normal working thickness of 13ft., but it has been proved under part of one estate in a bed 28ft. and sometimes 30ft. thick. This extraordinary thickness is purely local. At three miles off the seam is practically non-existent as a workable vein. Another seam varies from 4ft. to 12ft. thick. The change is gradual, and extends over about four miles of country. Beyond these instances the seams seldom exceed 4ft. 6in.

The yield of "large" varies considerably at different collieries, and would range from 81 per cent. to 58 per cent., while an average taken over the whole output would, in my judgment, give approximately 70 per cent. of large and 30 per cent. of small. A record yield known to me is 89 per cent. large, 11 per cent. small. This, however, is a special instance in a seam of exceptional hardness, and not over a large area of coal.

15744. Do these averages and these figures, which you give us, which you say are taken over the whole output, include the output of all kinds of coal, steam, and so on?—No, I am referring only to anthracite now.

The quantity of small coal thrown back into the workings on the "large and small" system varies from about 6 per cent. to 35 per cent. of the total coal sent out. Taking an average over the output of the whole field, I would say the quantity of small so gobbed would be 10 per cent. Of this I consider 50 per cent. would be marketable if sent out clean.

The economical effect of working the coal entirely as "through and through" may be better appreciated by a study of the following examples:—

1. Colliery working large and small, yielding, say two-thirds large and one-third culm, taking to-day's market value at, say, 13s. 6d. f.o.b. for large gives as a result £1 7s. for large, and 5s. for culm. Value of three tons, £1 12s., or an average of 10s. 8d. per ton.

2. Colliery working "through and through," yielding, say, one-third large and two-thirds culm, with the same selling prices gives two tons at 5s., and one ton at 13s. 6d., value of three tons, £1 3s. 6d., or an average of 7s. 10d. per ton; a difference in value of product (10s. 8d.—7s. 10d.) of 2s. 10d. per ton. The difference in cost of production in the altered circumstances would

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Mr. John Roberts.

18 June 1903.

not average more than 9d. per ton in favour of the owner. I am of opinion that less care would be taken if the coal were worked as "through and through," and consequently the market value would be appreciably reduced; while for much of the culm there would be on some occasions no market. I am confident if the workmen were given a free hand to send out all the small coal, and work the coal as "through and through," many of the collieries would of necessity be shut down unless there were an appreciable increase in the selling price of coal and culm.

The quantity of water made in the workings except at the outcrop, and in some cases in the lowest seams, is comparatively small. Most of the workings are "dry and dusty."

The workings from the collieries now in operation, and others already abandoned, have for all practical purposes proved the measures extending over a belt of country along the outcrops from Glyn Neath to Kidwelly—a distance of 30 miles—and having regard to the increased production during the last 12 years, there has been a corresponding increase in the number of lettings made along that belt. It is my opinion that, with only a small exception, the whole of the coal nearest the outcrop has been let. There is now no large area available except that which can be reached by sinkings of from 500 to 700 yards deep. The physical features of the country do not lend themselves to any shallower sinkings, since, as the depth to the seams increases with the dip, in the same direction the altitude of the surface increases, except in the valleys that intersect the country, and it is in these that future developments will probably take place. It is my opinion that as the developments extend to the dip, mining operations will become more difficult owing to the drier nature of the roof and to dislocations of various kinds.

15745. The whole of what you have said in your evidence up to the present relates to the anthracite field?—Except in the earlier stages. I have dealt with the anthracite field under the heading of anthracite; I now go to the steam.

15746. You have begun and dealt with it from the outcrop, as you call it; you are now taking the middle portion?—Yes.

THE STEAM COAL AREA.

This occurs in the middle of the field, and probably contains greater thickness of strata than either of the other divisions. The past workings have extended over a wide area, and have afforded the supplies of coal to the various iron, steel, tinplate, copper, and other manufactories of the locality. Only the Upper or Pennant series of coal seams have been won. This has been effected by pits and engine planes, the latter from the outcrops of the seams. Many of the older pits have been exhausted and abandoned. Any future sinkings to lower seams will involve the draining of extensive ranges of old workings which are now full of water.

The system of working most generally adopted is the pillar and stall, this being due to the fact that nearly all the Pennant seams are fairly thick, and do not possess roofs suitable to long-wall, nor is there sufficient rubbish for packing. There are only a few instances where thin seams occur, and they are worked profitably as low as from 18in. to 20in. thick of workable coal. The whole of the seams are worked "through and through," and I know of no case at present existing where small coal is gobbed in.

The dimensions of the pillars vary with the requirements of each seam, consideration being given to the nature of the roof and floor, thickness of the seam, strength of coal, and to the amount of squeeze or rising of floor, if any. In the thin seams referred to, the coal is worked out so clean as to leave a loss of only from 5 to 8 per cent. in pillars, while on the thicker seams the loss amounts to between 26 and 28 per cent. Taking an average over the whole of the collieries, I would set down the quantity lost in pillars at 20 per cent.

The quality of the coal in the whole of the Pennant series in this division is "friable," and, although high in calorific value, it is too tender for "carrying" to long distances. It is seldom shipped as large coal beyond the Mediterranean and the Baltic, but more generally as "through and through." Considerable quantities are used at the various manufactories in the immediate locality, while the small coal is employed for the manufacture of briquettes at the port of Swansea, which has the largest export of patent fuel in the kingdom.

The yield of "large" and "small" varies considerably. I know of no instance where the proportion of large has exceeded 66 per cent., while in several instances I have known a yield of small as high as 92 per cent. Taking the steam coal district within this area in the Western division as a whole, I would say the average yield of large is 22 per cent.

15747. You speak of the average yield of large as being 22 per cent. Is that under the system of payment for "through and through?"—Yes, "through and through." I know of no instance in this steam coal area where coal is worked on the large and small principle. It used to be so worked in some seams, but is not now.

15748. (*Mr. J. S. Dixon.*) What is the size of the screens?—1¼in. They vary, but 1¼in. is the common size. The larger percentage was with a screen of about 2½in., I think. There are two collieries where a coarse small coal is made.

15749. (*Sir William Lewis.*) That is where a special small is made?—Where a special small is made; it is used for patent fuel manufacture. It is made coarse, and the nuts are screened out from it. The percentage of nuts would be from 10 to 12 per cent.

15750. (*Mr. Young.*) There is only 22 per cent. left on a screen of that size?—Of large coal, yes.

15751. (*Mr. Brace.*) Would the men be paid upon the net large only?—No; the large coal does not come into calculation in the men's wages at all, where worked as "through and through."

15752. (*Chairman.*) That was my object in asking the question whether the percentage related to coal worked "through and through," because I am assuming that where it is worked "through and through" they are paid on the total quantity?—Yes, they are paid on the gross output.

The seams are not worked in descending order, but simply exploited in the order in which it best suits the coalowner to meet the requirements of the markets. To work the seams in ascending order, commencing with the lowest in this division, would be quite impracticable, since in some positions the depth to the lowest seam would probably exceed 2,000 yards.

In dealing with the collieries that are abandoned, I am of opinion that considerable quantities of coal have been rendered unworkable in the past by the lack of information where old and accurate plans do not exist.

In this connection I desire to express my view that the existing requirements in regard to plans of abandoned mines (Mines Acts 1887 and 1896) are wholly inadequate. I suggest that the plans to be lodged at the Home Office should be certified by two qualified surveyors, who shall hold certificates of competency as such under the authority of the Home Secretary. The workings should be inspected before abandonment, and plans provided with sections giving fuller details than is at present the case; moreover, I consider they should be available for inspection earlier than the time prescribed under the Acts referred to.

15753. (*Mr. Sopwith.*) That is 10 years?—Yes.

15754. (*Chairman.*) Shortly stated, that recommendation or suggestion means that before abandonment the accuracy of the plans which profess to represent the workings should be certified by such persons as you have described?—That is what I mean.

15755. (*Sir William Lewis.*) Such surveyors could only test the accuracy of the plans *qua* the particular portions of the workings then accessible?—Yes.

15756. (*Sir George Armytage.*) By whom are they certified now?—The provision is that they are to be provided by the owner and certified by the manager, but there is no provision in the Act as to the qualification of the manager; it simply provides, I think, that the plans are to be drawn by a competent draughtsman.

15757. (*Dr. Le Neve Foster.*) You are in favour of instituting certificates of competency for surveyors?—Yes.

15758. Different from the present manager's certificate?—Yes, I would have the mines surveyed by surveyors who are certified to be competent.

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15759. And who have been examined as to their practical experience and theoretical knowledge by some Government Board?—Yes, by some authority.

15760. (*Sir William Lewis.*) You, as one of the examiners on the South Wales Board, are aware that as part of the examination for managers' certificates surveying comes in?—It does, and in that capacity I am sorry I am unable to say that the efficiency in surveying is sufficient for good mining.

15761. (*Chairman.*) You will make some reference to that further on in your evidence?—I will.

THE BITUMINOUS COAL AREA.

This occurs mainly on the south outcrop, where the seams are highly inclined, and the system adopted is "Pillar and Stall." The seams are usually won by engine planes driven to the dip with level headings right and left from which "topholes," or stalls, are turned at right angles and driven to the true rise. The width of stall and size of pillar varies with the nature of the seam, the main object being to maintain a pillar that shall keep up main roads while working, and afterwards submit to being "split," or otherwise "robbed out," when "drawing back."

The lessee usually extends his main level headings in the strike of the seam towards the boundary, leaving pillars for the support of the main road. On reaching the boundary he reverses the operation and "draws back," or works outward towards the main engine plane by splitting each of the pillars previously left solid. While this is being done, new level headings are being driven forward towards the boundaries from a lower level on the engine plane, the distance between each level heading or gallery varying from 30 to 60 yards—or more—as may be best suited to the circumstances. Cross measure drifts are driven across the measures to intersect overlying and underlying seams, and the operation of opening out workings is repeated in these.

In well laid out mines barriers are left along the outcrops to support the surface, and at same time to keep up the crop water. In the past this precaution has been neglected, with the result that nearly the whole of the water finds its way to the dip in every seam. The "dip coal" is, therefore, "charged" with this water as a quantity to be drained before it can be reached, and has to be dealt with afterwards as a permanent subject for pumping operations. It is left to the will and pleasure of the lessor whether a barrier shall be left of sufficient dimensions to protect future dip workings, and where several properties are involved—some of them of small area—it is difficult to get proper precautions to this end. Although the reserves of coal may be enormous, there is a limit at which the working cost can bear excessive pumping charges, and it is at this point that those reserves cease to be of practical value.

I respectfully suggest that the Commission would do well to consider how far it might be desirable and expedient to recommend some State control or direction of such workings, having in view the possible loss of coal if the methods of the past are repeated indefinitely.

The loss on pillars left under the pillar and stall system I estimate at 20 per cent., to which must be added at least 20 per cent. due to plots of coal left, through workings being abandoned before the boundaries are reached.

I consider the long-wall system might be advantageously adopted in working many of these steep seams. This would reduce the loss in working to about 8 per cent., or a saving of 12 per cent., and in some cases more. The long-wall system has already been applied to the same seams in an adjoining district with great success, and with a loss as low at 5 per cent.

In the bituminous area a large tract of coal will extend under the sea as well as under the towns of Swansea and Llanelly. Due allowance should be made for the pillars required to be left in these circumstances—since long-wall working will be impracticable.

15762. Due allowance to be made by whom?—In the course of working by lessors; but my point now is that due allowance must be made for these pillars by the persons appointed by the Commission to compute the quantities of coal available in that part of the field, as well as for the loss that must occur arising from the east and west disturbances, and the many faults and folds that exist in this division.

GENERAL OBSERVATIONS.

Mr. John Roberts.

18 June 1903.

I know of no instance where coal in the anthracite field has been lost through gob fires or the like. There are two cases where through imprudent mining a small area has been flooded. Although it is not irretrievably lost, it is certainly placed under such disadvantageous conditions for working that its recovery is a matter that must be deferred to the far future. There are instances where parts of a mine have been temporarily flooded by striking out into old workings, but afterwards recovered, with some loss of coal.

In the steam coal area there have been several cases of spontaneous combustion where large areas of coal have had to be shut down.

There is an instance where very large areas of coal have been flooded through failure on the part of adjoining lessees to agree upon an equitable basis by which one could pump the water of the other. There is also an instance where a similar occurrence was threatened, and might repeat itself in the near future. These cases arise from the omission on the part of owners in past years to provide for barriers between adjoining properties and against the outcrop, with the result that extensive areas of old workings are connected, and the drainage is done by the worker at the lowest level, who has no legal remedy against those who are working on the higher level. The circumstances under which the cases referred to have arisen, coupled with the fact that much of the future of coal mining in the locality will involve heavy drainage, prompts me to suggest the adoption of some statutory measures on the lines of the South Staffordshire Drainage Commission, whereby lessors and lessees may have their interests adjusted by an impartial tribunal, and the person affording drainage be recompensed by a tonnage royalty, or otherwise, for coal recovered by means of his operations.

The failure to agree on the part of the persons interested in a case before me quite recently would have resulted in a large number of workmen being thrown out of employment. The risk of failure in the future, and the consequence of a stoppage, are such as to prompt me in urging the Commission to consider this question.

The seams are not worked either in descending or ascending order, but as the requirements of the time may dictate. For instance, seams that were at one time discarded, except for lime-burning and other similar purposes, are now extensively worked for the manufacture of patent fuel. The yield of small, it is true, is very great, but the coal is clean and best suited to the purpose to which it is now applied. Again, before the advent of the Siemens gas furnace, seams now worked extensively for gas-producing purposes were allowed to lie dormant. I do not think it would be practicable to work in any other way than is suggested to one by the demands of the various markets, and by the capital available for development. I have known seams worked together so closely as to bring creep on the upper seam, but the effect was to increase the cost of working rather than to cause any wastage of coal. I have never known coal lost in consequence. The impractibility of working the seams in ascending order, commencing with the lowest, may be understood on considering the fact that in one port of the steam coal area a pit to the lower seam would not be less than 6,000 feet deep.

There are no restrictions or obligations in any of the leases known to me whereby the lessee is to work in any particular order, and I am not aware of wastage having occurred through any obligation in mining leases. My experience is that the requirements of lessors are usually in favour of the lessee getting the largest possible quantity of coal to the surface and committing no waste.

15763. Would the method of payment also stimulate that?—The payment of royalty?

15764. Is the payment of royalty by ton and not by area?—I know of no instance in the South Wales Coalfield where the payment by area is applied; it is all by the ton.

15765. Output?—Yes.

The yield is greater by long-wall than by the pillar and stall system, and making a comparison of the two as applied to the whole of the Western Division, I would say that the loss in working due to long-wall would average 6 per cent, while by pillar and stall it would reach 18 per cent. This is exclusive of loss due to small coal gobbed in each case.

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Mr. John Roberts

16 June 1903.

The pillars get deteriorated by exposure to the atmosphere and by crushes—notably the latter, when the seam is thick—it is from this cause that the wastage by the pillar and stall system is so high. I do not know any other system that would apply to the circumstances. In leaving pillars the dimensions are usually determined by the nature of the roof, thickness and hardness of the coal.

There is very little "undercutting" or "holing" done in the anthracite seams. The slip cleavage is such that it is only rarely that holing is done. In the steam and bituminous coal districts much "holing" is done, but I do not consider there is any loss. Where the holing is done in the coal the product is usually marketable. Where it is done in any layer of carbonaceous shale or other substance the product is thrown into the gob.

The proportion left for pit support is very small. I do not suppose it would represent more than 1 per cent. of the area worked at each pit. Where engine planes are worked the pillars left to support the main road and return airway would not represent more than 1½ per cent. of the area worked, 50 per cent. of which would be recoverable on abandonment.

There is no fixed rule as to pillars left for support of buildings. Consideration is paid to depth, the thickness of seam, strength of coal, and nature of the overlying strata. There is no limit to the depth at which subsidence will not occur if the whole of the coal is worked away.

In this connection I desire to point out the enormous quantities of coal that exist under towns like Swansea, Neath, and Llanelly, where support to public and private buildings will be necessary; when the coal is worked; and, further, to the necessity in such cases of dealing with small freehold owners whose rights to property might interfere with or interrupt the progress of coal mining under those towns. I foresee the desirability at some time of having a means for dealing with mines under towns on the lines of enclosures of commons or waste lands: in other words, that an agreed area should be enfranchised under State control. Any enterprise for the development of the coal under either of the towns named might be blocked by a small owner, or number of owners, whose demands for royalties and wayleaves might be prohibitive. There should be a tribunal to deal with such cases equitably, in the interests of all parties concerned, including lessors and lessees, the workman, and the State.

I am of opinion that a large wastage of coal occurs in the indiscriminate and irresponsible way, from a national point of view, in which coal is being let. This does not apply so much to large estates where workable areas may be marked off and barriers left on mathematical lines, as in the case of a number of small properties where each owner does the best for himself. I produce a plan showing workings on one seam over a belt of country 8½ miles long. Nearly the whole of these workings are inundated, and the coal to the dip will, in sections, be liable to the head of that water. When the dip coal comes to be worked a very large wastage will occur in plots of coal left above any barrier that may be necessary to protect such new dip workings from water. These operations are being repeated in seams above and below the one to which the plan refers, but taking only the seam to which the plan refers there is a loss or wastage of 54 per cent., exclusive of the loss due to pillars left in working. (*Producing and explaining plan.*)

15766. (*Sir George Armytage.*) If all the landlords were put together into one authority, or if they could all agree to let to one lessee, there would be great saving?—If they could all agree to leave barriers at stated intervals, one compensating the other; the one who benefits to compensate the one who loses.

15767. (*Chairman.*) To supplement that, your point, as I understand it, is this, that even although this field were in one hand, in order to protect the working and to get the most coal out of the total area, a person taking a wider view of it would for protection, and for his own advantage, leave barriers at stated intervals?—That is exactly my point.

15768. And, therefore, whether in one hand or more, those protective barriers would be necessary for the general working of the whole field?—From a national point of view undoubtedly. I trust that for the future, and as the outcome of your labours, some means will be provided whereby the coal to the dip will be safeguarded by barriers that will not leave such a large area as this exposed to inundation.

15769.—Would that barrier as marked keep back the water?—Yes, but there are eight seams.

15770. (*Dr. Le Neve Foster.*) A similar barrier on every seam?—Yes. These operations are being repeated to-day. That is the mode of working in the locality, and it is being repeated.

15771. Irrespective of economy?—From a national point of view there is great waste.

15772. And from the landlords' point of view also?—Yes, undoubtedly.

15773. (*Sir George Armytage.*) How do you suggest it should be prevented? By some Act of Parliament, or something of that sort?—I am afraid I cannot put a scheme into a concrete form for you, but at the Court which I trust we shall eventually have (I might term it a Mining Court), all these points might be stated and the interests of the lessee, lessor, labour, State, etc., recognised, investigated, and protected.

15774. (*Sir William Lewis.*) Take this particular instance of a number of landlords; you do not think it is possible that they would agree upon this barrier?—No.

15775. Their interests would be so divergent?—Yes.

15776. Some might possibly have a large portion of the barrier in a very small property?—Quite so.

15777. And others with large properties might have a very small proportion of the barrier?—Yes.

15778. (*Mr. Sopwith.*) Have you made an estimate of the amount of coal in this barrier, 100 yards on the incline? It would represent an enormous quantity of coal?—Yes, I recognise that.

15779. You think that would be sufficient protection?—I think so.

15780. (*Sir George Armytage.*) Small freeholders might be put to the expense of leaving large barriers, and large owners having only to leave a small barrier. On the other hand, supposing the large owner was a man of foresight, and he purposely bought the estate because he knew it would be free from this great expenditure—how then? Perhaps he has paid more money for it. Would he then have to contribute still more?—It would be a matter for adjustment at the time. If he could show a loss, I think the matter should be adjusted.

15781. (*Dr. Le Neve Foster.*) What do you suggest as the tribunal?—A tribunal to hear all; every interest should have an opportunity of stating its contentions, and that tribunal should decide who should pay and who should not. I mean pay in kind.

15782. (*Mr. Sopwith.*) Would you go so far as to say that, if that barrier were not left there, the amount of water there would be so enormous that it would actually prohibit the working of the coal to the dip?—I would not go so far as that, but it would place it in such a position that it could not be worked profitably for very many years.

15783. Because of the cost of pumping?—Yes. It would be governed by the price of coal at the time; but in the meantime you are not fostering the industries in this locality because you are not doing what can be done to make this a working district. I submit that, always having proper regard for the interests of the individual there should be some form of State direction or control to prevent further waste occurring, for the protection of the person who will, by opening to the dip, afford drainage to others whose unworked coal may lie to the "rise." In the absence of such provision very large tracts of coal on the south outcrop and in the steam coal area will be rendered unworkable, until controlled by higher values for the coal produced; and by these means the increase of industrial progress in the districts under notice will be materially retarded.

Having regard to the large number of comparatively small collieries, to the fact that many of them are old, and to the class of machinery and appliance in use, as well as to the number of stop days from various causes, I estimate the consumption of coal for boilers would average 5 per cent. on the total output.

The requirements of the anthracite markets have been met by owners laying down installations of screening, crushing, and washing plant, whereby the coal is assorted into the following sizes, cobbles, German nuts,

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French nuts, peas, duff. I produce samples of anthracite coal as sorted for the market. There are already 21 collieries provided with machinery of this class, the plant most commonly used being to the designs of Messrs. Sheppard and Sons, engineers, Bridgend, who have made the construction of anthracite screening plant a speciality. It is seldom that the whole of the output of large is crushed, but rather only part—usually that passing over a screen with bars 5in. to 6in. apart. The crushing is effected by revolving crushers, and at a given point in the manufacture the crushed coal meets the "small" (culm) and is afterwards assorted into the required sizes and subsequently washed separately. When large coal is broken, three breakers are usually employed, so that the reduction may be as gradual as possible. When intermediate coal is broken, two breakers, and when cobbles are broken, one breaker is found sufficient for the purpose in view.

The loss in washing culm varies with the quantity of shale and other rubbish sent out with the coal, and ranges from 3 to 12 per cent.

15784. (*Chairman.*) Does the analysis of the quantity represented by that loss show that it contains much of value?—The waste?

15785. You say the loss in washing culm varies with the quantity of shale and other rubbish sent out with the coal, and ranges from 3 to 12 per cent. I will take the 12 per cent. for example. Would an analysis of that rubbish which represents 12 per cent. show that it had any value as fuel?—I would say no. I cannot give you an instance of analysis, but having the material present in my mind, I would say decidedly not.

15786. Therefore it is waste?—Yes, certainly; it is fine shale.

15787. And not available?—It has no marketable value.

15788. (*Sir William Lewis.*) That is shale which has been filled with the small coal and sent out with it?—Yes.

A small quantity of anthracite "duff" is used mixed with ordinary steam coal for the manufacture of patent fuel, but where this is done it is desirable that at least a similar quantity of highly bituminous coal should be used to produce a marketable fuel.

Many efforts have been made, and much money spent, to manufacture patent fuel from anthracite small or duff, but without any good results, owing to failure to produce a suitable agglutinant.

That most commonly used—and the only one with commercial success—is coal-tar pitch. When used with anthracite it happens that, during the process of combustion, the pitch volatilises much earlier than the coal, with the result that in a short time the briquette is converted into a mass of anthracite fine coal, which, unable to maintain combustion, chokes the furnaces—insufficient oxygen is admitted—and the fire dies.

The demand for "duff" is limited, and there are enormous heaps at nearly all the collieries where nuts and peas are made.

There is one coal-cutting machine at work in the district, but I am unable to speak as to its efficiency and economy.

I have never known a case where coal has been lost by reason of the owner's unwillingness to work it or grant leases to others.

15789. (*Chairman.*) Is coal lost by reason of there being no accurate plans or records available to show the extent of the old workings or explorations?—Yes. I feel that the plans of mines abandoned before the passing of the Mines Act, 1872, should be invited from coal owners and a register of same kept, and that the workings of all such mines should be prominently shown on the current working plans. The plans produced in the course of the investigations of the Commission show several areas of workings, of which there is no record at the Home Office.

I further submit that, where practicable, notice should be given to some responsible authority of any intended abandonment, and an inspection made by an independent person, who should more fully describe on the plan the workings and all dislocations and disturbances met with therein. The present provisions of the Mines Acts, in regard to plans of abandoned mines, are inadequate.

Barriers are left at the discretion of the lessor, and follow the course of the boundaries, except in cases where there is sufficient area to carve out, as it were one or more areas for working. It would be decidedly conducive to economy if there were an impartial authority to agree boundary barriers in the interests of all parties concerned. There is at present great loss owing to the existing methods of fixing barriers.

I have known several areas of old workings drained successfully through barriers from workings at a lower level, and by this means considerable quantities of coal have been recovered. I do not consider the present requirements of the Mines Regulation Acts adequate to the circumstances occurring in collieries where old workings are supposed to contain water. I submit there should be independent official investigation of all plans and other available data before any drainage operations to such old workings are entered upon. I believe this would save waste and would add to the safety of the persons employed.

In some cases where the circumstances would admit, the excess rubbish from one seam might be advantageously employed in stowing in another.

In many cases the long-wall system might be employed instead of the pillar and stall, and, where pillar and stall is essential, more of the pillars might be recovered than is done at present. A solution to each of these problems can, to my mind, be attained to a greater extent with higher knowledge of the principles of mining and better discipline on the part of the officials and workmen.

In the elementary instruction given in mining districts I would specialise on the subjects that are most likely to form part of the daily employment of those boys who will ultimately find their way to the mines; while in the technical instruction given under the auspices of the County Councils, I would enlarge its scope so as to attract young lads on entering the mines. In my capacity as one of the examiners for managers' certificates of competency, I have observed a marked improvement in the standard of knowledge displayed by candidates who have availed themselves of the instruction afforded by the lectures given at the University College, Cardiff, and by the County Councils of South Wales and Monmouthshire.

15790. (*Dr. Le Neve Foster.*) You are strongly in favour of Government surveyors being appointed by examination, or, rather, surveyors obtaining a certificate of competency from a Board appointed by the Government?—I am.

15791. What amount of attention is given to surveying in the present examination under the Board?—A paper is given exclusively on surveying. I may, perhaps, describe a question—I will endeavour to do so in a few words. The first question in the list given at the last May examination was this: "A colliery plan was made in 1818, when the variation of the needle" (I am giving you hypothetical figures) "was 24° west. In 1896 the pit was re-opened and headings driven in the following direction"—here were given the readings of a series of measurements taken—"with the object of reaching the old workings. Due allowance was not made for the difference in variation. Give the amount of error at the terminal point." I set the question myself. I had in view what I believe it is necessary that our managers should know more about—plans and surveys—and thereby add to the safety of working, especially where old working are concerned.

15792. Of course, that question is an excellent one, Mr. Roberts, but might not a person unacquainted with surveying, but still knowing that the needle does vary, be able to answer it?—I think if he did answer that question he would show sufficient proficiency in surveying to entitle him to the charge of the surveying at any colliery.

15793. Does that show that he has any practical knowledge of making an underground survey? Does it show that he has ever used a dial?—That in itself would not, but that is only one of a series of questions.

15794. Do I gather from you that you have one paper on surveying lasting three hours, perhaps?—No, not so long—about an hour to two hours.

15795. Does the man bring to you any certificate that he has had training in underground surveying and practice in underground surveying?—Where he has been trained in a mining engineer's or surveyor's office he does bring what is equivalent to a certificate; that is, he has to fill in a form which requires his employer to state that he has had so much training, but beyond that he does not.

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Mr. John Roberts.

18 June 1903.

15796. Does the training specify surveying?—Not separately.

15797. At all events, in your opinion it is insufficient?—It is.

15798. Do the other Boards ask a question on surveying?—Some of them do; I am not in a position to say how many, or to what extent.

15799. (*Sir William Lewis.*) I think you may assume that all the Boards do. We have a list of subjects sent down to us by the Home Office—I am speaking as Chairman of the Board of Examination—and the whole of the Boards of Examination in the kingdom have to test the candidates upon each of the subjects; but the actual questions, and the extent to which each subject is dealt with, are left to the discretion of the Board of Examiners?—That is so.

15800. (*Dr. Le Neve Foster.*) Is there any uniform standard in the examinations? Might there not be a district in some part of the United Kingdom where the standard of surveying is higher or lower than yours?—That is so.

15801. Is not the certificate, when it has been once gained by a candidate, available for the whole of the United Kingdom?—Yes, applicable to every colliery in the kingdom.

15802. Whether ironstone mines or any other mines?—Exactly—every mine.

15803. Is it not rather absurd that a certificate of a certain value should be granted upon an examination which is not uniform as regards standard?—I scarcely know how you could adopt a uniform standard that would apply to the various conditions of mining in the different parts of the kingdom; it would be too wide if it embraced all the methods of mining in the kingdom, as each coalfield has its own particular methods of working.

15804. But is it not the fact that the man who gets a certificate, we will say, in South Wales, where you have one method of mining, is at once allowed to go and manage a colliery in Lancashire, where things are different?—I admit that that is so, but there are many points where the examination would be uniform—questions on machinery, or ventilation, or geology—practically they are uniform now. Where the difference in each district occurs would be in questions appertaining to working coal.

15805. Is not the man who gets a certificate in your district at once able to go and get a billet, so far as the Government is concerned, in any other district in the kingdom?—That is so.

15806. And might not a man come from some other district to be examined in yours?—That is so, and they do.

15807. They find out which district has the easiest examination, I suppose?—I believe there is something in that.

(*Sir William Lewis.*) Then they do not come to South Wales.

15808. (*Mr. Brace.*) You do put them through the mill, Mr. Roberts?—Well, I think the examination on South Wales is a proper one.

15809. (*Dr. Le Neve Foster.*) You would suggest something far stricter, so far as surveying is concerned, for a surveying certificate?—Not necessarily. For the person in charge of the surveys at the colliery I would suggest a separate certificate.

15810. Apart from the managers?—Yes.

15811. A man might even get a surveyor's certificate without having got a manager's certificate?—That is my meaning.

15812. With regard to the pillars which you say would have to be left under towns, or under the sea, would it not be possible to work away those pillars and fill up the excavation—pack it entirely?—Not without disturbing the surface.

15813. Is that not done in some places abroad?—I speak from my own knowledge. My experience leads me to this conclusion, that there is no limit to the depth at which you will not disturb the surface, if you take away the whole of the coal, although you pack it. You cannot pack it as tight as it was in its natural state.

15814. Might not the amount of subsidence be so small as not to injuriously affect the surface?—I cannot speak to the extent of it. I know where it has occurred it has been sufficient to cause inconvenience.

15815. What was the packing done with?—The ordinary rubbish from a colliery.

15816. (*Mr. Dixon.*) I want to ask you a general geological question to begin with. Is there any theory as to how these somewhat abrupt differences in the quality of the coal have occurred as shown in your map?—There have been theories advanced, but I scarcely think they are a satisfactory solution of the problem. It is suggested that because of the thinning out of the strata and the thinner crust on the northern side, the radiation of the heat from the interior has carbonised the deposits of coal on that side; while on the south side we have the coal in its original condition, it being supposed that on the north side we have had it carbonised and caked up into anthracite; but that theory will not apply, because in other parts of the coalfield the crust is equally thin, if not thinner, and the coal above is bituminous.

15817. Is the change gradual?—I would say it is a gradual process probably from internal heat.

15818. Extending over an area?—It is not abrupt at all; the change is very gradual. I sincerely hope my evidence will not be misunderstood. I have said one cannot fix a geographical boundary, because the quality changes gradually from one to the other; it blends quietly.

15819. (*Chairman.*) And there is a point where it is neither one nor the other?—That is where what we call the dry steam coal is.

15820. (*Mr. Dixon.*) Is the eastern boundary of your plan a fault or an assumed line?—An assumed line.

15821. You said that the anthracite coal was mostly worked by the long-wall system, and that some of the seams were 13ft. and upwards in thickness. How do you work such a thick seam as that?—There are but two such thick seams, and those are only thick in one locality, the eastern end of the coalfield. Where they do occur the 13ft. seam is worked entirely by pillar and stall, and the whole height of coal is taken down. In other cases there is a layer of top coal of between 4ft. and 5ft. left up and timbered under.

15822. Which is the thickest seam you work long-wall?—I know of none thicker than, say, 5ft.

15823. You do not work any of these thick seams in two divisions by the long-wall system?—No.

15824. You said that of the small coal from 6 to 33 per cent. was thrown back. Do they wash small coal at all?—Yes, such as is sent out to the surface at a few collieries.

15825. Is there not a tendency in more modern times to take that coal out and wash it? There is a tendency to wash. We have now about eight or nine washeries built, while 15 years ago I should say there was not one.

15826. (*Chairman.*) Can you state at how many collieries out of the total number?—Without making a calculation I could not.

15827. (*Mr. Dixon.*) Is there a probability (from a national point of view) that in the near future all that will be recovered?—I do not think the coal that is now stowed in in some of the collieries can ever be recovered commercially; the roof will not admit of re-opening for it.

15828. I do not ask that; I mean in the progress of the workings?—You mean that the coal which is now stowed in will one day become useful?

15829. Yes.—Well, at present I know of no use to which it could be applied. The only hope I have is in the conversion of coal into gas in the manner of the Mond process.

15830. (*Chairman.*) Are you quite at one? Mr. Dixon is referring to the possibility of getting a larger quantity of this coal by improved arrangements in the future rather than opening out any old collieries and recovering the small?—I think I follow it.

(*Mr. Dixon.*) I think Mr. Roberts understands that. What I am wanting to get at with a view to the resources of the district is whether there is a probability of all this 6 to 33 per cent. being recovered in the immediate future.

15831. (*Sir William Lewis.*) That is in the course of the future working of the coal?

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(*Mr. Dixon.*) Yes.

15832. (*Sir William Lewis.*) Nothing to do with old workings?—Do you mean in the process of working?

15833. (*Chairman.*) The question, as I understand, put by Mr. Dixon, if he will forgive me for trying to disentangle it, is this: In reference to the coal which is now lost under the present system of working, by which this certain proportion of the small is stowed away, will the method of working in the future enable all that coal to be brought to the surface, or a portion of it, and, if so, to what extent?—In the seams now under consideration the process of working will be precisely the same as at present; the coal must either be thrown into the gob, or sent out. It cannot be sent out if there is no market for it.

15834. (*Sir William Lewis.*) But assuming a market in the future, a good deal of the small coal now thrown back into the goaf might be sent out?—Yes, if sent out clean.

15835. It could be washed?—Yes, if dirty.

15836. That has been the history of several districts where coal was left underground previous to the introduction of the washing process; it is now washed and sent away as duff. Might that process be introduced into your district?—The system of working will be precisely the same, and the coal will come out if it can be got rid of—and at a price.

15837. It is a question of market?—It is.

15838. (*Mr. Dixon.*) With reference to the losses that take place in pillars, which you have put down as 18 per cent., what sizes are the pillars, and at what depth from the surface. Take 200 yards from the surface; what size pillars do you leave?—Of course they vary in every seam.

15839. What proportion of coal do you work in the first working?—We work about 55 per cent. in the first getting.

15840. If you reduce that quantity do you not think that would enable a larger proportion of coal in the pillars to be got?—If I reduce that quantity in the first instance?

15841. Narrower stalls and larger pillars?—I should probably have considerably more small coal by working the narrow places. In a seam 9ft. thick you have the two side cuts, whatever width of stall there may be—wide or narrow.

15842. What size pillar do you leave?—From 12 to 14 yards of pillar in the first instance; and we carry a 7 yards stall into it.

15843. I suppose you are aware that in the north of England, and the best collieries of Scotland, only about 20 per cent. is worked by the stalls and 80 per cent. left in the pillars?—Yes, it is with a different roof from what we have, and a coal which is altogether tougher.

15844. The object of that is to recover the pillars?—Yes.

15845. Which are practically all recovered?—Yes; I do not think it would apply in this case.

15846. What do these losses which you speak of include, 6 per cent. in long-wall and 18 per cent. in pillar and stall? Do they include the loss by faults?—No, the loss in working the coal that is left in pillars only; they do not include loss due to faults.

15847. Does that include the coal thrown back?—No.

15848. You speak of taking rubbish from one pit to another. Has that been done in your district?—In this district it is not done. I am open to correction on that; I think in one colliery it is done to a limited extent. I have never done it.

15849. It is rather an expensive process?—Where two seams are worked at the same place it is not so difficult, but it is expensive; it is more convenient to deal with where you have a cross measures drift from seam to seam.

15850. You get the rubbish from one seam and lower it into the other seam; but suppose you have to haul it up?—Where long-wall has been worked in the bituminous coal that has been the method; the rubbish has been taken up an incline and let down into the workings from a higher level.

15851. Have you ever taken a plan of a colliery working and calculated the area excavated, and calculated the theoretical quantity that should have been produced, and what had been produced, and compared them?—Yes; unfortunately I have not got instances, but speaking from memory I have had within 11 per cent. of the theoretical quantity from a seam. In another case I have had within 13 per cent. of the theoretical quantity.

15852. What would be the average?—Of those two the average would be less than 12 per cent. of loss.

15853. (*Sir William Lewis.*) What was the specific gravity of the seams?—The specific gravity of anthracite coal runs as high as 1·42.

15854. (*Mr Dixon.*) You calculate the coal at that?—Yes.

15855. What does it work out to?—It works out to 1,700 tons per foot thick per acre.

15856. (*Mr. Teall.*) You have spoken of the inadequacy of the plans deposited at the Home Office, and I am not quite clear as to your reason for that complaint. Is the reason for the inadequacy due to the fact that the plans which are deposited do not come up to the standard required by the Mines Act?—No, I do not say that. With reference to the data required by the Act of 1896 and subsequently, I think the plans provide sufficient information.

15857. Sufficient data for the purpose you have in view, that is, the prevention of waste in the future?—Yes.

15858. The plans deposited at present are sufficient for your purpose?—The plans are sufficient where they give that data, and where the plans are made by a competent surveyor.

15859. That is going a little further; and that was the next point I was going to raise. Do you consider that the plans kept at the mines are sufficiently detailed and accurate for the purpose in question?—In large collieries, yes. In small collieries, where the plans are left sometimes to the manager, or sometimes to a surveyor, the plans are not adequate. I do not think there is sufficient attention paid to accuracy to meet the case.

15860. But assuming that the mining plans are accurately kept at the colliery, then the machinery for the accurate deposit of those plans with the Home Office works properly?—It works properly assuming the plans are correct.

15861. What is required, I suppose, is that a certified copy of the mining plans should be deposited at the Home Office?—Yes.

15862. And that is done?—Yes, but it is done in some cases by competent people, and in other cases by incompetent people.

15863. That is the original survey?—Yes.

15864. Then in order to secure that accurate copies should be deposited it would be necessary in certain cases, especially in the case of small collieries, to improve the method of surveying?—Yes.

15865. That applies only, I suppose, to the small collieries. In the large collieries the plans are accurately kept, practically, in all cases?—I believe so.

15866. Your suggestion is that steps should be taken to secure that all those who are responsible for the preparation of mining plans should be competent?—Yes, that is my suggestion.

15867. Not that any alteration is necessary in the Mines Acts of 1887 and 1896 in order to secure the proper record of mining observations?—Quite so.

15868. Then going back previously to 1896 the information at the Home Office is very imperfect?—It is.

15869. And there is no machinery for improving those records as the matter stands at present?—So far as I know there is no machinery.

15870. It would be very important that old records should be collected wherever possible for future work?—I quite agree.

15871. You suggest that the Commission should recommend that some steps be taken to secure the collection of this information which is in existence in the district with regard to old workings?—That is quite my view.

15872. (*Mr. Maclay.*) Do you find many landlords in the district which you know who refuse to lease the minerals on any terms?—No. I have known instances where landlords for reasons known to themselves have

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Mr. John Roberts.
18 June 1903.

preferred to keep the minerals, but I have never known coal absolutely kept idle. Coal that was held back 10 years ago is working to-day.

15873. (*Mr. Young.*) With regard to the 18 per cent. of small coal, is that coal, or is it partly coal and partly stone?—I was dealing with coal only.

15874. And it is actually 18 per cent. of coal?—Yes.

15875. If that coal were washed and sent away would it not bring a larger price than 5s.?—Some of it would.

15876. How much on an average do you suppose it would increase in price?—I will give you instances where the culm sent out—the small coal sent out—which would be practically the same kind of material as that which is stowed in, gave 53 per cent. and 58 per cent. of duff, which is sometimes sold for 1s. per ton, as often at 6d., and more often, I think, dumped on the pit head.

15877. Culm is not coal, is it?—Culm is the small of anthracite coal.

15878. And therefore it is not really coal that is wasted. There will be no means at all of making it available by bringing it to bank?—It is precisely the same as the culm or small coal which comes out, and which is dealt with for the market, so far as the markets are available.

15879. You speak of inconvenience being caused by working under the sea. What depth was that seam being worked when the water came in as you mentioned?—It was under a river, and it was very shallow; a very local case and a small one; 40 yards below the surface.

15880. Do you think there would be any danger in working under the sea at a depth, say, of 300 feet?—No, not at all.

15881.—The whole seam could be worked away in that case?—No, I do not think the whole seam could be worked away; you must leave pillars there.

15882. And the pillars would be lost?—Yes.

15883. At what depth do you think it would be safe to take away the whole seam under the sea?—I do not think it would be safe anywhere to take away the whole of the seam.

15884. Not at 1,000 feet?—No, I repeat there is no limit from my experience. I do not think there is any limit to the depth at which subsidence will occur if you sweep everything away.

15885. (*Chairman.*) You mean subsidence at the surface?—Yes.

15886. (*Mr. Young.*) If you take away the whole seam, supposing the seam is 6 feet thick, and it fell that distance, would not the interstices caused thereby be closed long before you got down 1,000 feet?—I do not quite follow you in the latter part of your question. Do you mean, if I worked out a 6 ft. seam of coal and filled it again with rubbish?

15887. No, I did not mean that. Take these two boxes side by side, and the seam worked out underneath; the seam drops *there*. Do you still think there would be space to admit water right to the seam?—What would occur would be this: there would be a displacement, a letting down, and some fissure or some spring which is *now* pent up would be drained, and you would find your water would come from the surface. I cannot conceive that anything but the relieving of water could have caused some of the instances of subsidence that have been brought to my notice. I have worked coal under the sea at 40 yards deep.

15888. (*Mr. Sopwith.*) In giving that answer you are dealing more especially with the South Wales district, where there would be a very great proportion of hard rock. If you have a great quantity of clay shale, and very little strong rock, and work long-wall, you would not make exactly the same observation?—So far as relates to the danger of bringing down the water, not in quantities that would be dangerous to life, but that would impede working and make it too costly, I still say that in the South Wales coalfield, where there are layers of shale, or where there are not layers of shale but rock, you would disturb the surface if you worked the coal wholly away.

15889. Where there is a great deal of shale and clay the space would fill up?—Probably, but subsidence at the surface would follow.

15890. You give evidence with regard to abandoned mines, and you consider that the period of 10 years, which is the period which the plans have to be deposited before they can be investigated, should be altered to a shorter period. Do you consider that that would be a direct advantage in enabling people within a more convenient period to ascertain the position of some of these abandoned mines?—Yes.

15891. You think it is a very important question?—I think it is sufficiently important to ask for an alteration.

15892. Would you put any limit to it? Would you say five years instead of 10, for instance? You must give some period?—I cannot quite see why there should be a limit to it at all.

15893. You think that they should be seen at once?—Yes.

15894. (*Chairman.*) That is for the inspection of the plans?—Yes.

15895. (*Mr. Sopwith.*) So long as they have been deposited any person could see them?—Yes.

15896. There is a very large amount of coal left under towns, you say. Have you formed any opinion as to the amount that would have to be left? When you were dealing with that question I did not quite gather whether you said that a great difficulty would arise on account of the freehold and copyhold, and whether you were also dealing with the question of subsidence and damage to buildings?—Yes, the two questions came in; the one as to the necessity of leaving sufficient pillars for the support of the surface, and the other as to the desirability of obtaining an easy means to secure those coals.

15897. I understand you to mean that you would have to leave such a large proportion, for the support of the buildings, that it would be very much the same as leaving coal under the sea?—I think so.

15898. Can you give any rough estimate as to what you think would be the quantity to be left under towns?—I should say at present that pillar and stall workings leave 20 per cent. of pillar, and that is sufficient to keep up the surface; but to make it absolutely certain I would say 33 per cent., or one-third.

15899. That is coming within a distance of, say, 100 yards?—I would leave it under the whole town.

15900. I mean the vertical depth?—I place no limit to that.

15901. (*Mr. Bell.*) With regard to the desirability of leaving barriers of coal so as to facilitate the working out of the waste in that large area of coal, shown on the plan which you have put in, have you any experience of other mining districts in the country?—No, only a general experience.

15902. Have you any opinion as to whether large quantities of coal are left underground in these barriers, dividing large and small areas belonging to different proprietors, which might be cleared away under the same kind of arrangement as that which you suggest for the dealing with this particular one?—I cannot speak from the knowledge of what goes on outside South Wales, but in South Wales it is done.

15903. You suggest that there should be a tribunal to which such questions should be referred, in the interests of the nation, I take it?—Yes.

15904. In order to avoid this large loss of coal?—Yes, in these peculiar circumstances.

15905. But if similar circumstances are found in other districts, in large and small areas, do you see any reason why the same sort of thing should not be done?—No, I would apply it everywhere. I think it would be equally fair where the circumstances called for it.

15906. Do you know, within your own knowledge, of any other districts where very considerable quantities of coal were left in barriers, dividing properties which barriers have been worked under such an arrangement?—I cannot speak from actual knowledge.

15907. But you would assume that such things do happen?—Yes.

15908. To a large extent?—Yes, I should say so.

15909. You would advocate that the same courts should deal with the questions generally?—Of a like kind generally.

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15910. And under such an arrangement a very considerable proportion of coal would be recovered and worked, which, under the present arrangement, is lost?—I think so.

15911. (*Mr. Brace.*) I note that you say in your proof and also in reply to Mr. Young, that about 18 per cent. of small coal is thrown back into the gobs?—Yes, in pillar and stall working.

15912. Recently they have been using anthracite small coal for the making of briquettes with a proportion of other small coal, have they not, Mr. Roberts?—That is so.

15913. The naval expert, or the gentleman who was here speaking for the Navy, gave in his evidence a statement that they have now been able to manufacture a briquette composed of anthracite and another kind of South Wales small coal, which was a splendid substitute for South Wales best steam coal in tropical climates. Do you know of these briquettes?—No, I do not.

15914. Assuming that the naval expert is right, and that the briquettes made of anthracite and other South Wales small coal prove a success as a substitute for steam coal, I suppose there is no reason why that 18 per cent. of small coal should not be brought out, if a market was found for it?—No.

15915. Then the reason why the small coal is left in is because for the moment it does not pay to work?—There is no market for it; and when there is a market it is generally sold only at a loss.

15916. To that extent that amount of small coal is literally wasted?—It is wasted—it is lost.

15917. (*Sir William Lewis.*) Have you any experience of burning small anthracite with other descriptions of coal?—I suppose I have had to do with the manufacture of as much patent fuel as any man living, having had 16 or 17 years of it, and I have tried all the mixtures, I think, extant. I have tried mixing anthracite with bituminous, but I have never yet succeeded in making a satisfactory patent fuel with a high admixture of anthracite. As I have stated, whenever the percentage of anthracite got to something like 10 or 12 per cent. of the coal used the buyers took exception to the quality of the patent fuel.

15918. Did you say when it exceeded 10 per cent.?—When it exceeded 10 per cent. Buyers always took exception to the fuel. French railway companies at once found it unequal to their requirements. I would say I have experimented with pretty nearly every agglutinant that has been brought to the public notice, at any rate, and I have never yet been able to make marketable fuel with anthracite alone, or even with anthracite with an admixture of bituminous that would be satisfactory in comparison with that which has been made from ordinary Welsh steam coal.

15919. Is there not this difficulty as to a combination of the different sorts of small coal, that while the bituminous burns, the small anthracite is left practically in a kind of coke afterwards?—Unfortunately it is not left in a kind of coke; it rather gets a kind of oiled fine coal, a kind of paste, if I may say so. What I wish to convey is this, that given a patent fuel made with 10 per cent. of pitch, each atom of pitch has to sustain the combustion of nine atoms of coal. If those atoms of coal preponderate in anthracite, the combustion is so much slower that the pitch volatilises, and what you have left is a block that was once hard and solid, now simply a mass of fine coal, kept together with a little pitch, or the volatiles left in the pitch, but giving no heat. Combined with the fine coal in this form they choke the furnace.

15920. Not giving the results required by the purchaser?—Quite so.

15921. (*Chairman.*) Practically the first stage of combustion?—Yes.

15922. Does anthracite require more of what you call the agglutinant to hold together?—Not necessarily to hold together. There again you have different grades of coal. With anthracite coal generally the atom under the microscope is more angular than a similar atom of what we call our steam coal.

15923. (*Sir William Lewis.*) Not the same fracture?—Not the same fracture, and speaking broadly, one could make a block of fuel with less pitch by using up anthracite than by using steam coal. I will not say in practice it would be desirable to do so, but in a laboratory test one would make it with less.

15924. (*Chairman.*) It requires more fire to consume or to keep burning the anthracite, and that is not supplied by the pitch in that case?—No, the pitch is gone.

15925. (*Sir William Lewis.*) With reference to your suggestion about the arrangement for accurate surveying of collieries, would it be difficult to provide in connection with the present Boards of Examination that persons going in specially for surveying should be examined upon the precise subjects necessary for an accurate surveyor?—The matter has not occurred to me as associated with the present Boards of Examination, but I certainly see no difficulty at all.

15926. Then I need not pursue that. With reference to your suggestion as to tribunals, am I right in concluding that the tribunals would be local Courts and not one general Court?—Well, I should have it a local court, but with representation.

15927. In each district of the Inspector of Mines?—Yes, of the Inspector of Mines. I would have some representative authority either in the person of the Inspector of Mines, or of someone attached to the Home Office, associated with that Court of Inquiry.

15928. With reference to the improved plans to be deposited at the Home Office when mines are closed, and as to means of checking them, I assume it would be impossible to secure accuracy except with respect to such portions of the workings as are then accessible?—You would secure the accuracy I desire in the provision of a certified surveyor all along; but the final checking could only apply to the workings then open.

15929. But with rare exceptions I take it you would admit that all the large collieries now have surveyors, who maintain accurate plans, which are kept up regularly, in accordance with the requirements of the Mines Acts?—All large collieries have, but I am afraid it is not so in smaller collieries.

15930. (*Chairman.*) I do not quite follow. There are two questions, one is as regards the future, and the other is as regards the past. I do not gather from what you have now said that you think it would be now practicable as regards the old plans, or rather the old workings which are not accessible, for any authority to obtain information as to those workings. That would be impossible, I agree. But your point is, as I understand (and that is quite clear, if I may say so), that as regards the plans deposited, let us say for small collieries, you would wish to secure, as regards the future deposits of plans, first that all those pillars that are accessible should be accurately represented on the deposited plans?—Yes.

15931. And you think that that can only be insured by having the certificate or the approval, if you like—that is to say, certificate in the sense of their being certified as accurate—of some competent surveyor?—Yes, or a certified surveyor.

15932. (*Sir William Lewis.*) You alluded to working under the sea. What particular collieries are you working under the sea?—I am working no colliery under the sea at the present time. I said "I have worked."

15933. Where was that?—In the Penclawd district.

15934. What cover was there?—About 40 yards.

15935. Was that worked pillar and stall?—Yes, I need not tell you that the water that came through the alluvial deposit was brackish.

15936. (*Mr. Brace.*) Of course, you worked the pillars coming back? You went on pillar and stall; did you work the pillars coming back?—No.

15937. You left them there?—Those that were split were split very little.

15938. (*Sir William Lewis.*) Did you leave much larger pillars there than you would under ordinary circumstances?—Yes.

15939. What was the thickness of the seam to begin with?—The seam was 4ft. 6in.

15940. One block?—Yes.

15941. What kind of roof?—Shale roof; what we should call clift; seam standing very steep—30°, and in some places 40°.

15942. What was the width of your drivages?—The level headings were about 4 yards from rib to rib—the rib on the upper side to the lower side.

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Mr. John Roberts.

18 June 1903.

15943. What size pillars between?—The top range was about 30 yards, measuring along the depth, and about 12 yards from pillar to pillar.

15944. What would you have left under ordinary circumstances with the same seam?—The width of the pillars there was about 12 yards. In the ordinary working I should have split every one of those pillars.

15945. You got none of them back?—We got a little—not much.

15946. Then following on that same subject with regard to subsidence, you assume that in the working of coal under the town of Neath and the town of Swansea, it would be impossible to work there without some arrangement by which the various small owners could be brought into line—so as to work it as if it was one property?—That is my view, also as regards Llanelly.

15947. What is the maximum depth of cover under which you have worked coal in your district?—I do not think there is anything more than 450 yards deep.

15948. What about subsidence then?—No subsidence with pillar and stall, but subsidence where the pillars were robbed.

15949. Have you worked long-wall under that?—No.

15950. Are you aware that in the eastern portion of the field, where the same seams have been worked under cover of 500 or 600 yards, there is regular subsidence throughout the district?—Yes, I am.

15951. You would expect the same when working the deep coals under those towns?—Quite so. I base my opinion partly on an experience in the eastern part of the coalfield. We are down to 560 yards; as the workings have progressed dipwards, so has evidence of subsidence occurred on the surface.

15952. Is it within your experience that material is taken from the surface for packing underground?—No.

15953. Do you know that that is a common practice in the steam coal workings?—I know it is.

15954. With regard to present practice, compared with the early part of your experience in the anthracite district, would you say that there is far more useful fuel obtained from each acre of the ground now than there was, say, 20 years ago?—Undoubtedly; the condition of things is so different. Pillar and stall in a great many instances has given way to long-wall working, and to that extent there is an appreciably larger lift of tons per acre taken over the whole field.

15955. Is there anything which you can suggest for the consideration of the Commission by way of improvement in the working of the remaining coal in those districts?—I have no suggestion to make. I think the matter is working out its own end, as it were, by owners closely studying the question and adopting long-wall where pillar and stall has hitherto been adopted.

15956. You mentioned nine collieries which were adopting the washing of the small coal. Can you send to the Secretary the percentage of the coal in the district which is dealt with by such washing machinery?—Yes I can.

15957. (*Mr. Bell.*) As to the suggested tribunal, you have no doubt thought this matter out rather carefully, and as I attach importance to the subject, I should like to ask you this: to whose initiative would you leave the matter in such a case, for instance, as a lot of barrier coal being left which might be worked if some arrangement in the interests of the nation could be come to?—I think it obviously should commence with the lessee.

15958. Which lessee—the lessee to the dip?—The lessee to the dip, in the first instance, of course.

15959. That is more particularly applicable, no doubt, to this particular district. But speaking generally, where it is a custom now for large broad barriers to be left as dividing lines between royalties, presumably, and no doubt generally in the interest of preserving these particular districts from water coming in from adjoining districts, the need for which barriers might by some arrangement in the interests of the nation be avoided by mutual concession or agreement—in the interests of the nation to whose initiative would you leave such a question?—I confess I have not thought it out sufficiently to give you an answer. It occurred to me that the first person affected would be the lessee, or a group of lessees.

15960. Supposing the Government Inspector of a district sees the development of a coalfield is taking place, so as to satisfy the prejudice of particular landlords, but in such a manner as to leave a large quantity of coal underground which would be entirely lost, would you suggest that he should be the proper man to make representations?—He is the only official who is in touch with the subject, but I am afraid his duties are already too many to attempt that responsibility.

15961. (*Sir William Lewis.*) Does it follow that he would know?—It does not follow that he would know.

15962. (*Mr. Brace.*) Not unless it was a distinct instruction to him?—Then I take it he would.

15963. (*Mr. Bell.*) You call it a local court. I take it you would have such a court with Imperial powers?—Yes, I think I suggested it should have some representative from a higher authority—from the Imperial authority—sitting upon it.

15964. I cannot suggest that the initiative should come from one of the particular lessors interested, but it seems to me to be a question which, in the interest of the nation, should be taken in hand by some Imperial authority—a Government representative?—Take the case that I referred to, where an area has been drowned; there two owners disputed as to whether the one should pay more or less pumping to the other—they failed to agree; the one pumping on the lower level found it impossible to continue; he abandoned, and the coal is left.

15965. (*Chairman.*) But they both suffered?—Yes, and a large area of coal was practically lost.

15966. (*Mr. Sopwith.*) That would be a question of making it a drainage area?—Yes.

15967. (*Sir William Lewis.*) Do you not think that, given the court, they would have plenty of grievances and plenty of people to put the grievances before them?—I think, given the means, these questions would appear. I agree with you putting it in that way. I cannot plan out the machinery that would work it; I only throw out the suggestion for you.

15968. (*Mr. Bell.*) You suggest that the Commission should make it one of their recommendations that some means should be adopted as the appointment of a tribunal by which the loss in coal should be avoided?—Yes; I would go a little further. I say that the Commission should suggest the machinery which you are now asking me to define.

15969. (*Chairman.*) Which you, with all your experience, are incapable of defining?—At this moment I confess I am unable to do so.

15970. You do not say that the problem is insoluble?—Certainly not.

15971. (*Mr. Sopwith.*) You did make a suggestion that there should be something of the same kind as they have in South Staffordshire, which should be general all over the country. It may be a question of pumping, but if by the establishment of a barrier you can prevent pumping, then there could be an apportionment of the charges. Your general idea was that some such tribunal should be established as the South Staffordshire Drainage Commissioners?—Yes.

15972. (*Chairman.*) If my recollection serves me, the principle of apportionment of payment under the South Staffordshire Main Drainage system was so much a ton upon the output, was it not?—Yes.

15973. If you are going to deal with properties containing coal, some of which may be got and some of which may not be got, some of which may be let and some of which may be unlet, how would you allocate the payment?—As regards the barrier, I would allocate it in area where it was possible.

15974. And therefore I, having a bit of coal under my land, but not wishing, or not being able to let it—not wishing, if you like—you would allocate to me what—that I should leave a barrier, or should contribute to the cost of leaving a barrier by somebody else for the benefit of my property or my portion of it, if ever it were worked? Should I be called upon to pay that in cash?—I do not intend that quite, but I should make you contribute either by leaving your coal or making your coal subject to a payment when it is worked.

15975. (*Sir William Lewis.*) Or by accepting a lower royalty from the person working it to the extent you are interested?—Yes.

15976. (*Chairman.*) That is all in the future. How would you secure that I should ever contribute anything

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at all, or that any contribution would ever be obtained from me. I assume that if you are going to levy a contribution upon me, you are going to give it to someone else, and you are going to give it to him in consideration of something which he has lost. How are you going to secure that the man who loses to-day when this decision is given, is going to benefit, if he is only going to get my contribution from me when my property comes to be worked? Mine may not be worked for 50 years in the natural course of things?—I would in some way make your minerals liable either in area or in charge to the satisfaction of this court. The court would mark out the barriers and allot that A. B. C. and D. should leave areas as they occur. Where the one leaves more than the other, some other equitable means should be employed to compensate the one who leaves most, and obtain that compensation from the man who leaves least.

15977. (*Sir William Lewis.*) Would it not involve this Court, if it ever is established, allotting all along this particular district the extent of the various takings; and of course they would have before them plans of the properties to be embraced in such taking?—Yes.

15978. And they would have to consider to what extent these various properties would have to contribute in respect of the benefit conferred upon them by leaving a barrier for their protection. One property would be perhaps 100 acres, another 50 acres, and another 30 acres, and they would contribute *pro rata* towards the protection secured by these means?—Yes.

15979. And contribute towards other properties which had no other interest in the particular taking?—Yes.

15980. (*Chairman.*) Their contribution would be in that sense a restriction placed upon some proportion of their property, that it should not be worked in order that it might form a barrier?—Yes.

15981. (*Mr. Maclay.*) Would you go the length of compulsion in the interests of a district?—It would have to be sufficiently compulsory to make the barrier a real one, not one to be left to-day and to be taken away later on by someone else.

15982-3. (*Chairman.*) The point, I understand, Mr. Maclay, is this: the witness wants in the first instance the power vested in someone to take a plan of the district, and to mark that plan in a certain form, in order that barriers shall remain undisturbed for the benefit of the working of the whole?—Exactly.

15984. (*Sir George Armytage.*) You mean shall be set out?—Yes.

15985. (*Chairman.*) Shall be marked out; and, as regards the future, the owners of the portions which constitute those barriers shall not be allowed to work them?—Yes.

15986. (*Sir George Armytage.*) They shall be required to leave them when the time comes to work their coal?—Yes, quite so.

15987. (*Chairman.*) In order that they should have no ground of complaint in equity, you say that they ought to be compensated in some form by the remaining portion to which such restrictions do not apply?—Yes.

15988. That is all clear up to that point. Now comes Mr. Maclay's question, which I do not think, if I may say so respectfully, is part of your scheme, because the method to be adopted apparently is compensation. There is compulsion as regards the restriction which is to be put upon property; but, given that, I am one of the persons who provide property, or from whose property a larger percentage than the average percentage is so ear-marked for barrier purposes, then the scheme is that I should be compensated in some form or another by the parties who are benefited by the barrier so constituted, to which I have contributed a larger area than my share?—That is my point.

15989. And the next step is the more difficult one: what form is that compensation to take? Is it to take the form of compensation in money; and, if so, how is that to be recovered from a man whose coal is not worked?—Yes, I cannot at this moment define it.

15990. With regard to the plans of collieries to be deposited, I gather that the difficulty arises with regard to small collieries?—Chiefly.

15991. May I put it in this way: would you say that it is likely or probable that it will arise with regard to any collieries which are opened in the future?—I think equally as much.

15992. You look forward to small collieries being opened?—Yes. The country lends itself to development by small collieries.

15993. I understand your answers to the questions to point to this—I am now looking at it purely from the point of view of coal resources—that in your opinion the whole of the small coal could be brought out and made available if it were worth while as a question of price?—Yes, it is a question of markets and prices.

15994. Have you any sort of idea as to the total quantity in tons which would be represented by the small coal which is thrown back or gobbed in South Wales?—If you take the anthracite output at 2½ millions and my estimate of 10 per cent. to be a fair one, you have a quarter of a million tons per annum. In the steam coal and bituminous coal there is none thrown back; I mean in the Western Division.

15995. (*Sir William Lewis.*) The steam coal there is worked through and through?—Yes.

15996. (*Chairman.*) You spoke of your experience with regard to the manufacture of patent fuel; and some reference was made to the evidence given by a witness from the Admiralty. Do the Admiralty buy any anthracite coal in the sense in which you have been speaking of anthracite?—Do you mean our duff coal?

15997. No, I mean coal?—Very little.

15998. Is anthracite used for firing any boilers in the Navy?—A very small quantity. I believe at Woolwich a small quantity is used—I am speaking quite from memory—but very little.

15999. As to the briquettes, of which the Admiralty practically control the manufacture, and which are made, as we were told by their witness, from the small which was obtained or produced, if you like, in passing down to the loading place; that small so made into briquettes would not come within your description of anthracite?—I have not quite followed, I am afraid. The experiments which the Admiralty have made would probably be from small coal obtained from large steam coal or obtained in the crushing of large.

16000. I can tell you what the Admiralty witness said: he said that they had some briquettes made from the smallest of the coal which they purchased for steam purposes, and which, as I understood, was obtained at the docks?—There is a double screening of steam coal. That is the best material that can be obtained, because it is large coal broken up into small. It is pure, and probably would not contain more than 2 per cent. of ash—if that is the coal.

16001. (*Mr. Brace.*) That is the coal: but there is a portion of anthracite mixed with it?—I understand.

16002. (*Sir William Lewis.*) They do not buy any anthracite for steam purposes?—No, very little, if any.

16003. (*Chairman.*) I rather gather that we shall find, when we come to read the evidence which has been given by you to-day, that we have possibly become a little mixed with regard to anthracite. With regard to these briquettes, I want to make this point clear, if I can, that the briquettes which the witness from the Admiralty spoke of as being made from the second screening of the coal which they bought for the ordinary purposes of the Navy were not anthracite in the sense in which you have been speaking of anthracite to-day?—Not by any means.

16004. (*Mr. Brace.*) I think you will find, if you look at the evidence, he does say that in the making of those briquettes there is an admixture of anthracite with these steam coal screenings?—I quite understand.

16005. Mr. Gordon Miller, in his evidence at Question 12255, is asked: "(Q.) Are those patent fuels made under your own supervision? (A.) Yes; we have an officer appointed to supervise the manufacture and to carry out tests to make certain that the ingredients are of the right description. (Q.) How do you secure that you get the quality of the coal free from foreign matter, and so on? (A.) Our patent fuel is manufactured from dock screenings of the coal that we purchase. (Q.) Then it really is the small coal out of the coal purchased by you? (A.) Yes, that is so—obtained in the second screening." Then the question was put to which Mr. Brace has referred (12265): "Then you are

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Mr. John Roberts.

18 June 1903.

hopeful that anthracite coal made up in that form may be more used for storing abroad? (A.) Yes, but the anthracite bears a comparatively small proportion to Welsh steam coal in the ingredients of the patent fuel"? —I quite agree. The gentleman who gave evidence, if he gave the quantity, I am almost certain would not say it exceeded 10 per cent.

16006. You gave instances of analysis of volatile matter in the "anthracite area," and you gave 11 per cent. to 4·25 per cent. of volatile matter; but you added: "In Pembrokeshire a coal containing a still less percentage of volatile matter is being worked." Is that an anthracite coal?—That is anthracite.

16007. Is there much of it in Pembrokeshire?—Pembrokeshire altogether is not a very big field.

16 08. Does it extend pretty well through Pembrokeshire?—Yes, although limited in area, it is of a very high quality.

16009. In giving us the areas you spoke of the anthracite area, or, rather, the area in which anthracite exists, and you gave that at 133 to 160 square miles. You pointed out also there were seams of anthracite in other of the districts mentioned, and you have told us that the output of anthracite coal in 1902 was about 2,500,000 tons?—Yes.

16010. Can you tell me what proportion or what percentage that represents of the anthracite that would be contained in that area?—I could not answer you right off.

16011. It is a question of calculation?—Yes.

16012. It is rather an interesting question, because it would indicate the duration of anthracite coal if got at this rate?—It requires careful consideration for this reason, that we have yet to decide, or at least we have yet to assume, a position where the 47 feet of coal becomes more than 47 feet in its travel southward. I think I explained that on the south outcrop we have 83 feet of coal, and that the thinning out from south to north occurs somewhere. We have not yet worked sufficiently to the dip to have much data for arriving at where that point is; but in working out the quantities that are being prepared for the Commission, that question will receive the serious consideration of those who are engaged, and it is only then that one could give you an approximation of the relative proportions of last year's output to the available quantity in the coalfield.

16013. Do you think that the field containing anthracite is fully known?—Along its outcrop, yes. I think the whole belt of 30 miles is well known. With the assistance that the Geological Survey has given, I think it is very well known.

16014. Does the coloured map which you have supplied to us represent the whole area, so far as you know, in which anthracite occurs?—Yes, subject to the explanation as to the lower seams under a portion of the other areas being anthracite.

16015. And if anthracite is required, is it your opinion that it will have to be obtained from the area which you have coloured blue on that map?—The area coloured blue and the areas to the dip.

16016. (*Sir William Lewis.*) The lower seams in the area to the dip?—Yes, to the dip.

16017. (*Chairman.*) Which is still unknown?—Unknown and it cannot be defined.

16018. You spoke of coal seams of I think you said 17 or 18 inches being worked?—Yes.

16019. You put it in this way, that you knew of seams as low as 17 in. being worked?—Yes.

16020. Had you in mind that there were seams of less than 17 inches in the same area which were not being worked?—Yes, there are several riders of less than 17 inches.

16021. Which are being left unworked?—Yes.

16022. In your general observations at the conclusion you say, "In the steam coal area there have been several cases of spontaneous combustion where large areas of coal have had to be shut down." Do you loo upon those as being permanently lost or only temporarily?—Only temporarily.

16023. Shut down in order to stop the firing?—Yes. In one instance they have been recovered.

16024. In speaking of the method of working, or order of working, descending or otherwise, you confirm what other witnesses have said, namely, that there is no order observed; but you did not touch upon a point which I think one of the witnesses touched upon, namely, that he thought it would be better if they were worked in a certain order, because by not doing that injury was done to seams by the crush. Do you attach importance to that?—No.

16025. That is a mere question of so much more small coal at the worst?—Yes, and perhaps more cost to work.

16026. May we exaggerate it as to its importance?—Yes, I think so.

16027. You say: "Any enterprise for the development of the coal under either of the towns named, might be blocked by a small owner, or number of owners whose demands for royalties and wayleaves might be prohibitive. There should be a tribunal to deal with such cases equitably, in the interests of all parties concerned, including lessors and lessees, the workmen, and the State." Would you contemplate the Court taking into consideration the benefit to be obtained by workmen or loss to be incurred by workmen in either of the circumstances?—The loss to be incurred by workmen in losing opportunity of employment.

16028. Which has never arisen?—Which has never arisen, because as yet no attempt has been made to open up these large areas of coal.

16029. That is a large question, is it not?—I foresee where in towns on a coalfield as these towns are——

16030. Where employment may cease——?—Yes. Where in the case of a mine opened, so far as regards that mine, it may come to an end.

16031. And then are you going to levy toll upon a man who does not let his coal in order that those workmen may be employed?—I would not do it in the interest of the workmen only, but in the interest of the lessee of a colliery opened for the working of coal under such an area, and of the nation in having less coal lost.

16032. (*Sir William Lewis.*) Does not that suggestion arise from the fact that in towns there will be properties held in very small plots, and if everyone, or even a tithe of the owners, wanted a wayleave, it would practically prohibit the working of the coal?—That is what I wish to convey. There may be 100 different owners of plots under the towns that I refer to, under Swansea, for instance.

16033. (*Chairman.*) I think I must have misunderstood the meaning of this. You mean that in your opinion it is desirable that a tribunal should be set up and the reason for that is the interest of all parties concerned; but you do not contemplate that that tribunal is to deal separately with, or examine separately, the interest of lessors, lessees, workmen and the State respectively?—Not except in cases of difficulty. Let me illustrate what I mean: suppose a lessee of a large area of coal under either of these towns opens a mine; he extends his workings; the workings reach two or three or a dozen plots of coal owned by small freeholders, or, in a great many instances, the ownership is not known—at all events, the identity of the owners is not known. I submit that those workings should not be suspended, but that the owner on depositing the value of the coal in the hands of some impartial person——

16034. The owner?—On the lessee, that is, the owner of the mine, agreeing to pay a reasonable royalty, it should be assessed by the Court so that he may continue his working.

16035. And pay it into Court for the interest of those whom it may concern?—Exactly.

16036. (*Sir William Lewis.*) It is a rare occasion when it is not known to whom certain plots of property belong in South Wales. It might have been so 500 years ago, but it is not so in the year 1903?—I refer to such plots as these; you may have building plots of one tenement or a dozen, and in course of time one of them gets lost or missed.

16037. (*Chairman.*) And the owner of the plot and the owner of the minerals being two different persons, are you going to compel the workings of those minerals, leaving the owner of the building to take his own risk?—No, the working of the minerals would be subject to such control as would be recommended by the Court, who would stipulate that proper support should be left

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16038. It might mean the leaving of the whole. However, I think Mr. Roberts, that you have answered the questions, at all events those about which I was in doubt?—I have endeavoured to.

16039. (*Dr. Le Neve Foster.*) With reference to what Sir William Lewis put to you in regard to an examining board for surveyors, would it not be better to have one central board to examine surveyors for the whole of the kingdom, so as to secure uniformity?—It might be better to have a general standard of examination in that case, but there would be no inconvenience caused if it were a local examination. *Mr. John Roberts.* 18 June 1903.

(*Chairman.*) I think I ought to say, Mr. Roberts, that you have given very interesting evidence, and, if I may say so, given it to us most excellently.

(*Witness.*) I am much obliged to your Lordship. I need hardly say that I am entirely at the disposal of the Commission.

Mr. MORGAN WILLIAMS DAVIES, A.M.I.C.E., called; and Examined.

16040. (*Chairman.*) I understand you had a long experience as a mining engineer at Swansea?—Extending over 28 years in the district. I am intimately acquainted with the anthracite coalfield, and have the responsible control and direction of several anthracite collieries—I also act as consulting engineer to several other collieries. *Mr. Morgan Williams Davies, A.M.I.C.E.* 18 June 1903.

16041. You have heard the evidence which has been given us by Mr. Roberts?—I have, and in general I agree with what he has said so far as he and I travel together; but Mr. Roberts has touched upon points which I do not propose to refer to in my evidence. With your Lordship's permission I will touch upon points which I think Mr. Roberts has not dealt with.

16042. Is the question of a tribunal one of the points you have in your mind, when you say Mr. Roberts has touched upon points you have not considered?—That is one. There is another point upon which I feel I ought to offer an explanation, and that is with reference to the deposit of plans. I shall have something to say about that, and I should like to have the opportunity of recounting my experience so far as the Inspectors of the district are concerned, if it is only in fairness to them.

16043. Then I will ask you to draw our attention to any points you think necessary?—Mr. Roberts has explained that the transition from anthracite to dry steam coal is gradual, following the dip of the measures the normal dip of which is uniformly southwards. The planes of transition lie at a very oblique angle from north to south, so that in many places where the upper measures are dry steam coal, the lower measures are anthracite. So that there is really no defined line of demarcation and the deeper seams are more anthracitic than the upper seams. At many points in the coalfield a pit would, in the upper stages, pass through coal of a bituminous or semi-bituminous nature, and in the deeper measures the coal would be gradually transformed into anthracite. Then there is another point with regard to the depth of the deepest winning we have in the anthracite coalfield. Mr. Roberts has given you an approximate depth, but the precise depth is 234 yards, and that is the depth of the deepest shaft of the Gwauncaegurwen Collieries. The coalfield is intersected by a number of faults, the normal course of which is north and south. These faults materially alter the sections of the seams of coal, and their inter distances tend to reduce the thickness of the seams, and to increase the thickness of the intervening strata as we advance westwards. I have with me here a section of the various coal seams as proved in different parts of the coalfield. It is on a very small scale. (*Produced.*) *Supplement Plate 24.*

I agree with Mr. Roberts that no coal has been left unworked because of fire.

16044. Lost, not left unworked?—Quite so—lost; nor is there any coal that has been absolutely lost because of water.

As to the working of the measures, they are worked regardless of order; the most profitable are worked first. In bygone days, when local ironworks and blast furnaces were in operation, certain seams of coal peculiarly adapted for iron smelting were extensively worked. These seams consisted of alternating beds of coal and thin laminae of carbonaceous shale, which latter served to hold the coal together and resist decrepitation in the furnace under blast. In those days the superior coals of to-day were found unsuitable for iron smelting because of their friability under blast, and as the demand for anthracite coal for other purposes was very limited these seams were not worked. To-day the circumstances of the market have altered, the coal that was formerly in demand for iron smelting is regarded as a second or third rate coal, because of the ash it leaves, hence it is that these seams are only very partially worked. Coal of this quality has in recent years been sent to Cumberland and to Stockton, in limited quantities, when the price of coal was low for iron smelting, but there is no regular demand for it.

16045. Can you give particulars of seams worked in descending order or otherwise, and the effect upon other coal seams above or below them?—The principal seams of anthracite coal now worked are the following:—The Red Vein, which is the uppermost of the series. The Big Vein and the Brass Vein, or seams corresponding to them known by other names. In many collieries where these seams do not occur, or where they have been worked out, the lower measures are worked. The coal seams of these measures are comparatively thin, varying from 2ft. 3in. to 2ft. 10in., but the coal is generally of good quality, and it commands a high price, otherwise the high cost of working would be prohibitive.

16046. What order of working would, in your opinion, be most conducive to the economy of the coalfield, and insure the getting of the largest quantity of marketable coal when brought to the surface?—I would favour the working of the coal in descending order so far as it could be done. Of course where seams of coal are not of a suitable quality for marketable purposes it could only be done at a disadvantage.

16047. Is it usual to find in leases any obligations on the lessees to work the seams in any particular order or manner?—The leases in the anthracite coalfield are, generally speaking, of an open character as regards restrictions of working, and it is exceptional to find any obligations on the lessees to work the seams in any particular order.

16048. Are you aware of any cases where loss or waste is due to the operation of obligations or restrictions in mining leases?—I am not aware of any cases where loss or waste is due to the operation of obligations or restrictions in mining leases.

16049. How is the coal worked in your district?—Mr. Roberts has to a great extent explained the method of working to you. Both the long-wall and pillar and stall systems of working are in operation, but where the character of the seam and the roof is suitable, long-wall is invariably adopted. In the eastern section of the anthracite coalfield the seams are thick, and would not yield sufficient rubbish to stow up the goaves if worked on the long-wall system. In these cases the mode of working is invariably by pillar and stall. The section of the seam in these instances varies from 6ft. 6in. to 9ft., and in some places up to 12ft. and 14ft. The plan of working under such circumstances is to drive headings having ranges of 60 to 70 yards, from which stalls are opened out to a width of about 6 to 8 yards leaving pillars of 8 to 10 yards between them. When the stall has attained the limit of its range the pillars are withdrawn, sometimes by working directly backwards from the face, and sometimes by working forward in blocks in successive stages, that is to say, an opening is made into the pillar 15 or 20 yards back from the face, and that block is worked forward to the face. A second cut is then made into the pillar at a distance of 30 or 40 yards back from the face, and that block is, in its turn, similarly worked. In this manner where the roof is good the pillars are worked without much loss, but the coal is essentially crushed to some extent. In my opinion the latter method is preferable to the working backward continuously of the pillar from the face, because the squeeze or crush on the coal is interrupted by thus working it in successive stages. Where the coal is abnormally thick it is worked in two stages. A

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stall from 4 to 5 yards wide is driven forward in the bottom coal, leaving the top coal as the roof to be supported on timbers.

16050. (*Professor Hull.*) What do you call "abnormally thick"?—Beyond 9ft. From 6ft. to 9ft. is the normal thickness of the seam.

When the stall has reached its limits of length it is filled up as far as possible with rubbish and a narrow road is driven forward in the top part of the seam. Where this method is adopted, there is no room available for stowing, and the coal is filled out as through coal. In some cases where the roof is not suitable for working by long wall, a system of double road stall is adopted.

16051. (*Chairman.*) Does the coal in the pillars become deteriorated by exposure to the atmosphere and by crushes in pillar and stall working, and what is the loss in consequence?—I agree with what Mr. Roberts has said on this point. In pillar and stall working, the coal in the pillars, as the effect of crush and exposure to the atmosphere, is weakened, and to an extent it is lighter in weight bulk for bulk than coal worked from the solid, but much depends upon the dimensions of the pillars. Generally speaking the larger the area of the pillar the less is the crush felt on the coal.

It is difficult to estimate the loss in working pillar coal because so much depends upon local conditions. In one stall the pillar may be almost wholly worked back, whereas in another stall in which the pillar is being similarly worked back, a crush may set in on the road and close it. Under such circumstances a part of the pillar would be lost.

Generally speaking where the pillars are strong Pillar Coal would give off from 5 per cent. to 15 per cent. more small coal than coal worked from the solid, but where small pillars are left the proportion of small coal would amount to probably from 70 per cent. to 80 per cent.

16052. (*Mr. Young.*) That is, there would be 20 to 30 per cent. of large coal got?—Yes, 20 to 30 per cent. of large coal got where the pillars are small and the seam is not very strong.

16053. (*Chairman.*) Do you think that loss could be prevented by any other system of working?—I do not think it could be prevented by any other system of working that it would be practicable to adopt.

16054. What is the proportion of large and small coal obtained under the different systems of working?—The proportions of large and small coal vary very considerably, and may be anything between 15 per cent. and 40 to 42 per cent. of small coal. It may be well here to define the term "small coal," as known in the anthracite district, and to explain the system of separating it from the large, which is this: the coal as brought out from the colliery is tipped over a screen, the usual angle of inclination of which is 19 degrees with the horizontal, or 1 in 2·9; and the screening-surface, consisting of bars ⅞in. to 1in. thick on face spaced 1¼in. apart, is 9ft. 0in. long measured along the axis of the screen, and 5ft. 9d. to 6ft. wide, thus giving a screening surface of 51 to 54 square feet.

16055. Do the bars run longitudinally?—Yes.

All the coal passing through this screen is small coal. In some working districts where the coal is hard, cuts well, and is filled out entirely as large coal, the proportion of small it contains on screening does not exceed 15 per cent., but it frequently happens at the same colliery in another district that the coal is soft, and has to be sent out as "through and through" coal, in which case the proportion of small is at once considerably increased. In the Big, or Nine Feet, seam, as worked in the Swansea and Dulais Valleys, the proportion of small coal to large varies from 30 to 40 per cent. of the gross output. In the collieries producing this coal the method of working is by pillar and stall, and most of the coal is gotten by the aid of explosives. In bye-gone days the mode of working usually adopted was to carry forward a long cut on the leading side of the stall which disengaged the ends of the cleavages, and the coal in the successive cleavages was wedged out without resorting much to the aid of explosives. By that method of working the percentage of small was considerably less than it is at present. Unfortunately, the collieries that were used to that method of cutting are rapidly dying out.

16056. (*Sir William Lewis.*) Do you get the cleavages regular in the pure anthracite?—Yes, very regular.

16057. At what distances apart?—About 18in. to 2ft.

16058. (*Chairman.*) In cases where pillars are left for a temporary purpose is it better, with the view to the ultimate recovery of the coal, to make those pillars small and numerous, or large and few?—Where pillars have to be temporarily left in thick seams, I have experienced that the larger the dimensions of the pillar within reasonable limits the better, and especially so along the main roadways. In thick seams, such as the Nine Feet, great difficulty is often experienced in the maintenance of the roads, because of the heaving of the bottom, and once the cutting of bottom is started it has to be continued. I have, at one of the collieries under my charge where the Big Vein is being worked, adopted pillars of 50 yards in width on each side of all main roadways, with the result that no trouble has been experienced over the heaving of the bottom, or in keeping the main roads in repair. In my judgment it is better to make the pillars, where the roof is strong, of large dimensions.

16059. Is any of the small coal thrown into the gob?—The percentage of small coal thrown into the gob varies, as nearly as I can estimate, from 10 per cent. to 18 per cent.

16060. That is lost coal?—Yes.

16061. (*Mr. Brace.*) So that you agree in this particular with Mr. Roberts?—Yes.

16062. (*Chairman.*) Any holing?—Holing, as a rule, is not extensively carried out in the anthracite coalfield, but where it is in operation the loss due to it is comparatively inappreciable.

16063. There is not much water in the anthracite field?—No.

16064. Can the same be said of anthracite seams which are in the other field?—I anticipate the same will be the result. Of course, they are of greater depths. One does not know what the working will be.

The workings as already stated are at comparatively shallow depths, and the reservation of areas to serve as shaft pillars, or as pillars for the support of buildings, is not at all considerable. There is no fixed proportion allocated to varying depths.

16065. Is there any great waste or loss by barriers being left, which might be avoided by arrangement?—The reservation of barriers along boundaries is not often observed in the anthracite coalfield, but there are instances of such barriers, and where such occur the coal contained in them will probably be lost. These barriers are left principally as a buffer between two collieries, and I am of opinion that on the principle of avoiding the connection of the workings of one colliery with another, probably to the detriment of one or the other, any satisfactory mutual arrangement could not, in the majority of cases, be arrived at.

16066. Are barriers left to prevent the influx of water?—In cases where the workings of a colliery approach old workings full of water, barriers are left for the protection of the modern workings. In some instances old workings have been unwatered, thus doing away with the necessity of a barrier.

16067. What proportion of coal obtained is used for colliery purposes?—The proportion of coal consumed for colliery purposes varies from 3 to 8 per cent., depending upon the output and the capacity and character of the mechanical power in operation. In most mining leases an allowance of 5 per cent. of the total output is conceded free of royalty for colliery purposes.

16068. (*Mr. Brace.*) Why is the 5 per cent. allowed free of royalty?—In most instances it fairly represents the actual consumption for colliery purposes.

16069. (*Chairman.*) It is not saleable in fact, you would say?—No; it represents the quantity of coal consumed by the colliery.

16070. And therefore, for that reason, cannot be sold?—Quite so. It is not available for sale.

16071. (*Mr. Brace.*) It is for that reason you do not pay royalty upon it?—In other words, it is coal employed for working the coal.

16072. (*Mr. Young.*) The landlord gets just as much as he would do if it were differently arranged?—No, there is a rebate in the royalty. The royalty account is made out, and from the total amount this is deducted. The landlord has to concede it.

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16073. It would be a less amount per ton if he had so much upon every ton?—It has to be taken into consideration at the time the lease is granted.

16074. (*Chairman.*) Have you any coal-cutting machines?—So far, coal-cutting machines have not been introduced into the anthracite coalfield.

16075. Do you know of any case where coal is lost, either by reason of the owner's unwillingness to work it, or grant leases, or give facilities for passing through?—I cannot recall any case where coal has been lost through any obstruction offered to working by the royalty owner.

16076. Do you know of coal being lost through inaccurate plans?—The inaccuracy of old plans has not, in my experience, led to the loss of coal, but in many instances it has very seriously increased the cost of opening out through old workings, the extent of which have been invariably under-represented. I have known of several instances where the cost of opening through old workings has been very greatly increased because of the inaccuracy of old plans to the extent that they did not sufficiently show the area of the old workings.

16077. That, of course, was an expenditure which was lost?—Yes.

16078. Is it possible, do you think, to reduce the amount of coal lost by using rubbish from the surface for stowing?—I have no doubt in some instances rubbish from the surface would enable coal to be brought out that is not now brought out; but, according to my view of the unmarketable quality at the present moment of anthracite small coal, the cost of taking the rubbish in would be much greater than the value of the small coal left behind.

16079. (*Sir William Lewis.*) It would exceed the value of the small coal?—That is so.

16080. (*Chairman*). Do you think there is any likelihood of the small coal at present left underground, or consumed in large heaps upon the surface, being utilised by the discovery of new uses for it?—In connection with this question it would be well to state that at several of the principal anthracite collieries, mechanical screening machinery is employed for the separation of the coal into various classes, to suit the requirements of the market, thereby reducing the waste to a minimum. The usual classification is the following:—

Large coal.—Passing over a screen the bars of which are spaced 3½in. to 5in apart.

Cobbles.—Coal passing through a screen of 3½in. to 5in., and over a screen having circular or rectangular holes of 2¼in.

French nuts.—Coal in irregular cubes of 2¼in. to 1¼in.

German nuts.—Coal in irregular cubes of 1⅜in. to ⅝in.

Peas.—Coal from ⅝in. to $\frac{5}{16}$in.

Duff.—From $\frac{5}{16}$in. downwards.

Duff coal, ranging in proportion from 12 to 18 per cent. of the output is generally an unmarketable commodity, but small quantities are occasionally sold for the purpose of mixture with bituminous small coal for the manufacture of patent fuel. At most collieries where mechanical screening is in operation there is a large quantity of duff in stock, at many collieries amounting to thousands of tons.

As to the yield of several seams of coal I have actual results here, and I ought to state that these are under normal conditions of workings; no faulty ground or disturbances have been taken into account, only districts in different collieries where the coal is worked under normal conditions have been selected. They are as follows:—

	Section of Seam.	Mode of Working.	Yield per Foot per Acre.
1.	Clift top:		
	Shale with two courses of rashes - 2·9-in.	—	—
	Clod - - - - - - 1·3-in.	—	—
	Coal - - - - - - - 2·3-in.	Long wall - - -	1,260 tons.
2.	Clift top:		
	Clift - - - - - - - 2·2-in.	—	—
	Clod - - - - - - - 0·10-in.	—	—
	Coal - - - - - - - 3·10-in.	Long wall - - -	1,326 tons
3.	Clift top:		
	Clod - - - - - - - 0·3-in.	Pillar and stall.	—
	Soft coal - - - - - - 0·4-in.	Double road stall.	—
	Coal - - - - - - - 2·7-in.	—	1,462 tons.
4.	Clift top:		
	Coal - - - - - - - 5·0-in.	—	
	Coal - - - - - - - 1·9-in.	—	—
	Coal - - - - - - - 1·0-in.	—	—
	Coal - - - - - - - 3·6-in.	Pillar and stall - -	1,354 tons.

16081. (*Professor Hull.*) What is the meaning of the word "clift"?—Strong shale; it is a term used locally.

16082. (*Chairman.*) You have already told us that with regard to the yield per foot per acre these quantities which are given are the quantities which are brought to the surface and passed over the weighing machines?—That is so.

16083. Therefore these quantities are exclusive of the loss of small coal, if any, which is thrown into the gob or left in the pit, and exclusive of the coal left for pillars?—No, there are no pillars in this case; it is worked by long-wall.

16084. Pillars left for protection of buildings or what-not, I mean. I want to get it clear whether it is so or not?—It does not include pillars for buildings. In this particular colliery there is no pillar left at all, with the exception of a shaft pillar. In this instance it represents the gross produce of a certain area of coal underground; it covers two headings, and all the stalls opened out of them.

16085. (*Sir William Lewis.*) What is the acreage? Can you give it over 15 or 20 acres, say?—I am afraid I have not gone so extensively into it as that. I have taken a district of about 5 or 6 acres.

16086. Is it large or through coal?—As it is passed over the weighbridge it is filled as large coal.

16087. Large coal trams do contain a certain amount of small coal?—The contents would be about 15 to 18 per cent. of coal which is included in this yield of 1,260 tons per acre.

16088. (*Chairman.*) You say that these figures represent the quantity brought to the surface and passed over the weighing machine, but they are the quantities which have been the produce of an area in which no pillars were obliged to be left for any purpose?—That is so. In the case of No. 2—the 1,326 tons—that applies also. In the next case, No. 3, the method of working was pillar and stall, and very small pillars were left; so that the pillars left underground have been included in this instance. Then the total produce of No. 4 was 1,354 tons, and the same observations apply.

16089. Therefore we have what appears to be a paradox, namely, that the output or yield per foot per acre is greater in pillar and stall where pillars are left than

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Mr. Morgan Williams Davies, A.M.I.C.E.

18 June 1903.

by long-wall where no pillars are left?—That is so in this case.

16090. (*Sir William Lewis.*) Only it is not the output of large coal, but it is the output of large coal and small?—In the latter case it is the output of the large and small, so that would make the difference.

16091. Are these taken in the same neighbourhood, or in the same colliery, or in the same seam?—No two are in the same seam. The first two are in the same colliery, but in different seams.

16092. Could you give us the names of the seams in each of the instances?—Yes. No. 1 is the Grasissa Vein, the second is the Stanllyd Vein, the third is the Red Vein, and the fourth the 9ft. Vein—the Big Vein. Nos. 1 and 2 are in the Pantyffynon district, No. 3 is in Ystradgynlais, and No. 4 is at Abercrave, Swansea Valley.

16093. You have heard the answer given to me by Mr. Roberts as to the improvement in the yield of coal in the anthracite district by the present arrangements compared with what they were 20 years ago?—Yes.

16094. Do you agree with that?—Yes. Where long-wall has been adopted there has certainly been an improvement, and long-wall has been adopted wherever it can be adopted within the last 20 or 25 years.

16095. Do you suggest anything to the Commission by which an improved output could be obtained from the amount of coal lying in the ground?—No, I am afraid I cannot.

16096. With respect to the quantity for marketable purposes?—I am afraid I cannot, unless it may be possible, by the introduction of coal-cutting machinery at some future time, to effect an improvement.

16097. (*Mr. Young.*) You spoke of a change in the method of working the anthracite seams. Miners previously used to cut away in front of the main face and work it out by cleavage?—That is so.

16098. At that time the small was considerably less than at present?—Yes.

16099. Can you give us the difference in the percentage of small?—Unfortunately I cannot give it to you exactly, because my experience of the method of working by that long cutting was obtained at one colliery, and my experience upon the other points at another colliery, but I think the difference would be fully 10 per cent., if not 15 per cent.

16100-1. What was the special reason for changing the method of working?—It was more laborious to cut manually than to work it by explosives.

16102. There is a loss of about 10 per cent. by the present method as compared with the former method?—Yes, undoubtedly; I should put it at at least 10 per cent.

16103. Would you not, by that margin, be able to pay a considerably increased price for working by the old method in order to save that quantity of coal?—That is a question I could not deal with at the moment. No doubt if the coal could be cut with less breakage it would be beneficial to everyone, to the cutter and to the colliery company alike.

16104. You are practically losing about 10 per cent. of the quantity of coal you have in the anthracite seams where a change has taken place in the method of working?—In those places where the coal was formerly worked by long mining in stalls, and where it is now worked by explosives.

16105. That is very strange, that you are by the present method of working losing about 10 per cent. of the anthracite seams?—It is so.

16106. Especially when—I think you will agree with me—you could pay something extra which would make it worth while for the men to work the old method and save that 10 per cent.?—No doubt that is a question which would rectify itself. It is a question which would arise at once. The greater the amount of large or round coal produced, the better it would be for the colliery owner and the workman; and I have no doubt some arrangement might be made whereby the cutting price would be increased if a greater proportion of round coal could be got.

16107. You also spoke of the quantity used for colliery consumption as ranging from 3 to 8 per cent.; what is the reason of that difference?—There are many reasons. First of all, we have a number of stop days, unfortunately, in the anthracite coal district. The pumping machinery, where pumping machinery is in existence, has to be kept going in some collieries, and where pumping is not resorted to, or where the haulage lead is not so long, we are able to work with less mechanical power than in others, but the important factor is the loss of time during stop days.

16108. Does it differ considerably in different collieries?—Yes.

16109. On account of not having trade, or the men not working?—The men not working.

16110. There is a considerable difference, you think, between the men at one colliery and another?—The difference between one colliery and another is the difference between the amount of work that has to be done. Some collieries you may find equipped with modern plant, and they have not much water to pump; other collieries you may find equipped with plant of a very antiquated type, and they have a lot of pumping to do, and they are placed at a very considerable disadvantage as compared with the others.

16111. (*Professor Hull.*) Is not anthracite of a higher specific gravity than ordinary bituminous coal?—Yes. The specific gravity of anthracite coal varies from 1·38 in the eastern part of the district to 1·42 in the western part. I cannot go as far as Pembrokeshire, but I believe the coal of Pembrokeshire is of a higher specific gravity still; taking an average, it is 1·4.

16112. You would not apply this estimate to ordinary bituminous coal?—No; the bituminous coal may vary from 1·29 upwards.

16113. That is to say, generally, anthracite weighs more per cubit yard than bituminous?—It is the heaviest coal. We have that at once evident in the difficulty of washing anthracite coal. There is little difference between the specific gravity of the smaller particles of the coal and the shale associated with it, and a lot of the coal is carried away in suspension.

16114. In one of your instances I see you give the coal as 2ft. 7in. and clod 0·3in.?—In that seam the bottom has to be cut in the roadways, and that has to be stowed away so that it fills the gobs, and the small coal is brought out. That accounts for the high produce.

16115. (*Mr. Teall.*) Do you agree with Mr. Roberts that steps should be taken to complete the records in the Home Office by, as far as possible, collecting information as to old workings in the districts?—Yes, certainly.

16116. You think it would be possible to improve the records as to workings so as to make it more economical to work in future in that district?—I believe it would be possible with a little effort to obtain a quantity of information that has never been deposited at the Home Office. There are plans of old workings which were in operation some 60 or 80 years ago in the possession of people connected with the colliery owners or the officials at that time, which might be got hold of, and which would be of considerable value in supplementing the information at the Home Office.

16117. Of considerable value in this respect, that it would probably save waste in future—that is, save unnecessary expenditure of money?—Yes, and give, at all events, an approximate idea of the extent of workings of which there is no record whatever at the present moment.

16118. You think that is an inquiry that the Government ought to undertake?—Yes, so far as possible.

16119. (*Dr. Le Neve Foster.*) With regard to the inaccuracy of plans, do you agree with Mr. Roberts that it would be a good thing to have certificated underground surveyors?—Well, there I foresee a difficulty. It would be a very valuable thing, no doubt, if some competent officials in the Imperial service were employed occasionally to go round in much the same capacity as one of His Majesty's Inspectors of Mines does at the present moment, to see that the plans are properly carried out: but to delegate that authority to any practising engineer I hardly think would do, because we find there are objections to the examination of plans by anyone who is not perfectly impartial and is in any way connected with the industry.

16120. I think you misunderstand me. The point is this: some plans, at all events, at the present time,

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according to what Mr. Roberts said, and what other people have said, are not well kept—are inaccurate, perhaps—at some collieries. Would it be a good thing that every underground surveyor should be certificated in the same way that a manager is certificated?—Yes, I think it would.

16121. What Mr. Roberts proposed was that there should be a special class of persons holding Government certificates to the effect that they were competent to survey mines, and that it would not be legal for anyone else to make the official survey?—I think that would be a very desirable thing, because in many instances plans have been made by people from surveys conducted, and plans kept, by persons not competent to do it.

16122. Is it possible for a Government Inspector, in making his rounds, to satisfy himself of that unless he makes another survey?—No.

16123. He is not safeguarded?—No. I do not think any Government Inspector would assume the responsibility of certifying the accuracy of a plan unless he had had the opportunity of testing it for himself.

16124. Do you see any other way in which one can insure accuracy of mining plans all over the kingdom?—Not without periodical checks. In all large collieries the accuracy of the plans speaks for itself; surveyors are employed, and certain drivages are made, and those drivages intersect one another, and if in any one case the length of drivage should be over or under what it ought to be scaled on the plan, then the surveyor has to account for it, and his services would probably be no longer required if on more than one occasion he was proved to be inaccurate.

16125. With reference to the point of 10 years during which the plan has to be deposited before it can be seen by the public without special leave from the Secretary of State, is there any reason why it should not be seen the very next day now?—In my opinion there is every reason why it should be, for this reason: a colliery may be abandoned, and someone else may take a mineral area immediately adjoining, and it is very unfair that he should not have access to the plans for a period of 10 years, because it may be necessary for him to know what the extent of the other workings was.

16126. You advocate a change of the law in that respect?—Yes.

16127. (*Sir George Armytage.*) That is the law now?—It is the law.

16128. (*Sir William Lewis.*) There are such cases as colliery owners trespassing on each other's property. Some of the Commissioners probably have experience of that?—That is so, no doubt.

16129. (*Dr. Le Neve Foster.*) You give us excellent information about the definition of small coal after the coal has reached the surface. How would you define the small coal left in the goaf? How is that separated from the large?—It is not separated at all. The practice is to fill as much large coal as possible in sending out the coal. *Mr. Morgan Williams Davies, A.M.I.C.E.* 18 June 1903.

16130. Is that done by means of a fork?—With a fork into a box, as a rule.

16131. It would be the interval between the prongs of the fork which would decide which was large and which was small?—Yes.

16132. What size would it be?—About seven-eighths to an inch.

16133. You do not allow them to fill with shovels?—Where large coal is filled, not at all.

16134. With regard to your computation of the amount of coal per foot per acre, are you taking into consideration in any way the dip of the seam?—I have taken that all in.

16135. Your computation is per foot per acre if the seam were flat?—Yes; it is reduced to horizontal measurement.

16136. You say clod means clay. I suppose you mean a hard clay?—It is a hard clay; it disintegrates very readily when brought out on to the surface, but it is so hard that it has to be out down by the pick underground.

16137. The only difference is that one is laminated and the other not?—Quite so.

16138. (*Sir George Armytage.*) In making the surveys in your district, is it usual for the lessor's surveyor to make them, and the lessee's surveyor to inspect them, or does the lessee's surveyor make them and the lessor's surveyor check them?—As a rule, the lessee's surveyor makes the survey, and in some instances the lessor's agents checks the lessee's surveyor's plans—in other instances the lessor's surveyors survey for themselves, so that there is a check.

16139. As a rule, which is the first one?—The lessee's surveyors, as a rule, keep the plan; in fact, invariably.

16140. (*Sir William Lewis.*) With respect to check surveys, is it not the practice at most of the large and well-managed collieries for the surveys to be checked from time to time, in addition to carrying on the regular surveys of the stalls and headings—perhaps once in a year—especially when you are approaching the boundary?—Yes, from the pit bottom.

16141. Is that not sufficient to ensure the accuracy of the surveys and the plans?—It rarely happens that there is an inaccuracy in a large colliery. If there is one, it is a minor one. So far as all main roads are concerned, they may be taken to be accurate.

Mr. E. R. Fisher, called; and Examined.

16142. (*Sir George Armytage.*) You are able to give us some evidence with regard to the South Wales anthracite coalfield?—Yes. I may say my evidence coincides with the evidence of Mr. Davies. I can describe the South Wales' anthracite coalfield and the qualities of coal found there. *Mr. E. R. Fisher.* 18 June 1903.

16143. What is the general section of the coalfield?—Sections vary greatly between neighbouring collieries. The seams at the eastern end are thicker than those in the middle portion, and the seams in the middle are thicker than, but not so numerous as, those in the western portion of the field. In the western and middle districts the thickness of coal contained in seams over 12in. is as follows:—Western portion, 52ft. in total thickness; middle portion, 57ft. in total thickness; eastern portion, 50ft. in total thickness, that is only in the lower portion below the Red Vein. Why I make that reservation is this: I do not feel competent to say what is anthracite once you get above the Red Vein in that district—it is getting a little bit out of my ken down there.

16144. Under ordinary circumstances, what proportion of coal is usually left behind in working the different seams?—In pillar and stall work, 20 per cent., and in long-wall working 10 per cent. under ordinary circumstances, the reason being that up to the last few years small coal was a drug, and at times practically unsaleable.

16145. What proportion of coal is destroyed or rendered unworkable by extraordinary circumstances such as fires, floods, etc.?—By fires practically nil. By floods up to the present time very little, quite infinitesimal.

16146. Are the seams worked in descending order, or are the most profitable seams worked first without regard to the effect upon other seams which may be injured thereby?—As a rule the most profitable seams are worked first.

16147. Can you give particulars of seams so worked, and the effect upon other coal seams above or below them?—I can in several cases. Case A. A seam 6 ft. to 9 ft. thick worked first, and over-lying a seam 2½ ft. to 3 ft. thick, 8 to 12 yards of ground lying between. The lower seam was very hard to get, and required an abnormal quantity of explosives, consequently it produced a much larger quantity of small and unsaleable coal. When worked *vice versa* the upper seam was not affected to an appreciable extent. Case B.—A seam 4½ to 5 feet thick, worked first, overlying a seam 3 ft. to 3½ ft. thick, 8 yards intervening between the seams. The lower seam was worked 12 to 14 years afterwards, was very tough and hard to get, and made an abnormal quantity of small. Case C.—Three seams worked, the upper one 2⅜ ft. thick, middle seam 2¾ ft., the lower seam 5½ ft. thick. The middle seam was worked first,

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Mr. E. R. Fisher.
18 June 1903.

and a thickness of from 4 to 6 ft. of strata worked above the seam for ironstone. The upper seam 20 yards above was then worked, and no appreciable difference found. Ultimately the lower seam 35 yards below the middle seam was worked, and no appreciable difference found. Case D.—A seam 4 ft. thick worked first, then a lower seam 2 to 2½ ft. thick, 25 to 30 yards below, was worked, and no appreciable difference was found; in fact, the lower seam was not affected. The greatest factor to be taken into consideration is the distance between the seams.

16148. So that practically, in your opinion, it comes to this, that it does not much matter which is worked first so long as there is plenty between?—So long as there is plenty between.

16149. What order or working would, in your opinion, be most conducive to the economy of the coalfield and ensure the getting of the largest quantity of marketable coal when brought to the surface?—My experience has been that it is best to work the lower seam first. I will not say that as to the working of the coal.

16150. Will you give the reason for that?—In working your lower seam first you leave all your troubles behind you when you come up to the next seam; you have nothing to trouble you about water, or keeping pillars for the support of the upper seam. When I started work in 1875 we had in one seam a very long adit level a mile and a quarter long. In dry weather there was very little water, and in wet weather there was enough to turn a mill-wheel. When we worked the next seam below that we had to leave a pillar all along to protect the adit level. We had to go down below and leave further pillars. In one case where, through the negligence of the officials at the collieries, this pillar was neglected, it gave us a very large amount of water: by good luck we were able to prevent any more water coming down, but it cost a lot of money to get over that difficulty.

16151. In that particular colliery you would have done better if you had worked the lower seams first?—Certainly.

16152. You would not say that that would apply to all?—No, I would not say that; in fact, it would be impossible in some cases.

16153. (*Sir William Lewis.*) Where you had the preference you would do it?—Yes, I say where it is possible.

16154. (*Professor Hull.*) Water is the special reason?—Yes.

16155. (*Sir George Armytage.*) Is it usual to find in leases any obligations on the lessees to work the seams in any particular order or manner?—Not usually in my experience.

16156. Are you aware of any cases where loss or waste is due to the operation of obligations or restrictions in mining leases?—Not to my knowledge.

16157. Have you any suggestion to offer as to the best mode of insuring the prevention of such waste and loss of fuel?—Well, I do not think I am competent to answer that.

16158. On what system is the coal worked?—Long-wall principally. Decidedly the larger yield is given by long-wall, which is the system most in vogue in the coal-field. Pillar and stall is worked largely in the thicker seams of the eastern portion of the field, and the upper seams, including the Red Vein all over the field, are generally worked by pillar and stall. Practically the whole of the seams in the middle and western portions are worked by long-wall.

16159. In pillar and stall, or bord and pillar working, does the coal in the pillars become deteriorated by exposure to the atmosphere, and by crushes, and what is the loss in consequence?—The coal does become deteriorated, principally by crushing. The question of loss in consequence is determined by the size of the pillar left. If small in area the percentage of loss is greatly increased. The quality of the roof has also to be taken into consideration. Many pillars have been wholly lost. Again, on the other hand, in a well-laid out district, and with a good roof, the whole of the pillars can be removed. I have in the Red Vein practically got all the coal and brought it to bank, and the same way in other seams, when filling through and through coal, If only large coal is filled, then the percentage of loss will be quite 15 per cent. of the pillars.

16160. Could that loss be prevented by using any other system of working?—Yes, by leaving larger pillars and removing them in a short period of time, or by working long-wall, if possible, or some systematic method of packing and gobbing.

16161. What is the proportion of large and small coal obtained under the different systems of working?—Long-wall working should not produce under ordinary conditions more than 20 to 25 per cent. of small; pillar and stall working under same conditions, 30 to 35 per cent.

16162. In cases where pillars are left for a temporary purpose, is it better, with the view to the ultimate recovery of the coal, to make those pillars small and numerous, or large and few?—Large and few.

16163. Is any of the small coal thrown into the gob or goaf and lost, and how much?—On an average 10 per cent. at least is gobbed and lost.

16164. (*Sir William Lewis.*) Is that 10 per cent. avoidable?—I do not think it is.

16165. Any portion of it?—Well, I think it is as broad as it is long.

16166. (*Sir George Armytage.*) Is there much loss by reason of the undermining or holing being wastefully made in good coal?—No holing is done in the anthracite dirtrict, therefore there is no loss from this cause.

16167. What proportion is left in ribs or pillars for shaft surface, or other support?—There are very few shafts at work in the field, and the surface support is not usually required. The conditions of the coalfield do not demand any requirements of this character, therefore the loss from this source is very slight.

16168. When coal has to be left unworked for the support of buildings, etc., on the surface, is there any fixed proportion of coal left according to respective depths?—The same answer applies. The question of support of buildings, etc., owing to the general configuration of the ground, seldom arises, therefore no fixed proportion of coal is required to be left.

16169. Is any coal now being left behind which might be worked out without occasioning more damage than the loss of coal would amount to; and can any suggestion be offered by which this loss of coal might be prevented?—My previous evidence will apply to that question. In general, I would prefer working out the coal in preference to leaving a pillar for support. I might say that why I speak of the general configuration of the ground is that nearly all the collieries are on the outcrop and situate on the side of steep valleys. Therefore, in a very few yards you are really under a great thickness of ground, and the surface does not want any support, and you have no buildings to support. A great portion, however, is worked from under common land, I should say.

16170. Could any of the portion now left be hereafter recovered, and at what additional cost?—Anything that has been left in could be got, but at a prohibitive cost.

16171. Are barriers of coal left along the boundaries of the different properties, or between the colliery takings?—Not as a rule, between properties. In a very large number of cases the properties are small, and a number of them are leased together to form an average sized taking; they are then worked out as a whole. Barriers are left in some cases around or between the colliery takings. But the anthracite field is so much cut up with faults and disturbed ground that in a great many cases these form natural barriers between the takings.

16172. Is there not great waste and loss by such barriers which might be avoided by arrangements independent of the property owners?—I cannot say a great amount of waste is caused by these barriers. A certain amount might be done away with on the same estate, but I do not think it would be the best policy to do away with them.

16173. Are barriers of coal left to prevent the influx of water from old workings? Have any steps been taken to drain such old workings, so as to recover the coal so left? If so, with what amount of success?—Barriers are left against drowned workings, and as a rule the cost of pumping would be much more than the value of the barriers so left. In several cases the barrier can again

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be worked, so that this loss in quantity is only temporary. I know of very few instances, however, of the sort.

16174. Do you mean you know a few instances of barriers being left, or do you mean you know of a few instances of their being got?—A very few instances of the barriers being left.

16175. What proportion of coal obtained is used for colliery purposes?—About 5 per cent.

16176. Have coal-cutting machines come into use, and on what principle, and with what effect, either in saving of cost or in yield of coal?—Coal-cutting machines have not come into use in the coalfield.

16177. Do you know of any case within your experience where the coal is lost either by reason of the owner's unwillingness to work it or grant leases to others to work it, or to give facilities for passing through his property?—I know of no cases of that sort.

16178. Is coal being lost by reason of there being no accurate plans or records available to show the extent of the old workings or explorations?—In this coalfield the amount of coal so lost is very small indeed.

16179. Would it be possible to reduce the amount of coal left for pillars by utilising the rubbish for stowing and packing to a greater extent than at present?—It might be possible in some cases.

16180. Do you know of any cases?—Well, in thick seams, no doubt, if they were systematically packed, you might get more of the pillar out.

16181. Do you know of any cases?—No, I do not.

16182. Do you think there is any likelihood of the quantity of small coal at present left underground or consumed in large heaps upon the surface being utilised by the discovery of new uses for it?—A large proportion of the small left underground might be utilised by screening and washing; but as for the large heaps on the surface (if by this is meant the "duff" from nut-making plants), so far it is a drug, and any process by which it could be utilised would be a boon to all concerned. Some such process may be conceived in the future; at present a certain percentage of it is used in patent fuel manufacture. More small coal would be raised could this duff be turned to account.

16183. Do you know of any other circumstances by which avoidable waste is caused, and can you suggest a remedy?—No, I am not aware of any.

16184. You think that on the whole everything is being got to the best advantage?—I think so at the present time—things have improved very much.

16185. (*Dr. Le Neve Foster.*) You said you did not think it mattered what order of working was adopted for a succession of seams, provided there was plenty of space between two adjacent seams. What would the limit of "plenty" be—how much?—I have mentioned cases where 8 to 12 yards was sufficient, and I have mentioned cases where 20 yards was sufficient, so that it would be something between the two.

16186. The anthracite is not got by holing at all. Are there plenty of joints or cleavages or cleats, or whatever you like to call them?—It is full of cleavages.

16187. How far apart are they?—Anywhere from 9in. to 12in. or 18in. We call it very far if it gets 2ft. 6in. to 3ft.

16188. Is it got by wedging?—It comes out itself if it is long work—it works itself. With long work and anything like a face it comes out.

16189. You say this duff or fine anthracite cannot be used for fuel. Do you know whether it has been tried in the Meldrum furnace?—Yes.

16190. It has not succeeded?—Well, you can burn it.

16191. Can you burn it so as to raise steam by it?—Yes, but not to get power. You could if you had twice the boiler power; in other words, you would require twice the boiler power.

16192. And therefore twice as much fuel?—Yes; what I mean is that if you have a certain number of boilers doing a certain amount of work with ordinary coal, you are not going to get the ordinary amount of work out of those boilers by burning duff.

16193. Supposing the duff is far less than half the price of the coal; what would be the price of the duff?—We will make a contract for any quantity at 1s. a ton.

16194. Might it not be worth while, then, to use it for steam-raising purposes in some special furnace such as the Meldrum furnace?—I say the only place I know where they are working with duff they are using egg-end boilers, and they have a man to shovel out the dust as fast as another man shovels the duff on the fire. There remains the fact that they pay more for labour than the value of the coal.

16195. At times that is so?—Not always, perhaps.

16196. Has it been tried at all with the furnace we heard of the other day—the Schwartzkopff?—Really I could not tell you.

16197. You know that system—blowing it in with a jet of compressed air?—I do not think it has been.

16198. (*Mr. Maclay.*) Did you hear Mr. Roberts' evidence?—Yes.

16199. Do you take the view that it would be desirable to have some such Court as that which was discussed by the Commissioners and Mr. Roberts?—Really I cannot say I have given it due consideration. I only heard of the idea for the first time this morning.

16200. Your evidence indicates that in your opinion things are satisfactory as they are?—I think things have very much improved during my experience of the last 25 years. I know there is a very great difference now to when I started work.

16201. (*Mr. Young.*) Is this dust or duff, that you referred to a moment ago as being practically impossible to burn, the dust made in the cleavages?—It is the duff that accrues in the working of the coal—it is the breakage of the coal.

16202–16203. The lumps ground into powder would burn as well as the dust which Dr. Foster referred to?—Quite.

16204. I think you said that the anthracite coal was generally worked under what was common land?—Yes.

16205. Is it common land still?—What I mean is that there are no buildings, and very little cultivation; it is on the mountain side. I will not say it is common land.

16206. The royalty is owned by landlords?—Yes.

16207. (*Sir William Lewis.*) Have you anything to suggest to the Commission by way of improvements in the mode of working, so as to obtain the largest possible quantity of useful fuel from underground?—No, I have not.

16208. Is it possible, by sending out more of the small coal which is thrown back now, to get more coal?—I do not think it is, and I will explain why. That coal is put into the gob with a shovel; most of the seams in the anthracite district have a clod on them; it may vary from a few inches to a few feet thick; it comes down either before or with the coal. What the first man has to do is to turn this stuff away back into the gob. He puts the small coal in. We get it out dirty enough now, filling large, but if they had it all out every colliery would have to follow our example and put up a washing machine. We found three or four years ago that we had to do that to give us a chance of living along with our neighbours.

16209. If you brought out more of that, would you require to take in some other material for gobbing?—Well, perhaps not. I do not say that we are going to get very much of that 10 per cent. that I calculate is left underground in the shape of profitable coal; we should get a certain percentage of it, but we should increase our percentage of duff, and it would be as broad as it is long.

16210. Suppose, for instance, a greater number of collieries were prepared to expend the capital necessary for putting up washing machinery, would there be sufficient inducement then to bring out a larger quantity of that small, which is now thrown back into the gob?—I do not think so.

16211. (*Sir George Armytage.*) You mean it would not pay to bring it out?—Yes. I think there are ten—eight or nine, at any rate—collieries fitted up with washeries, or preparing to fit them up. They are not merely talking of it, but are doing it. They are all the best coal collieries, or good coal collieries. Now a large portion of the small coal made in second-class collieries you could not utilise at any cost, even if you put up washing plants. It is not of the quality which buyers want as good coal.

16212. So that the advantage of washing is limited to the superior quality of coals?—Yes.

16213. That is your experience?—Yes.

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Mr. Thomas Seymour, called; and Examined.

Mr. Thomas Seymour.

18 June 1903.

16214. (*Sir George Armytage.*) You are a colliery manager?—Yes, I am Manager of the Pontyberem Collieries, and I am Chairman of the Swansea Board of the Monmouthshire and South Wales Coal Owners' Association.

16215. And you can give us some evidence with regard to the anthracite coalfield in the western portion of Carmarthenshire?—Yes.

DESCRIPTION OF THE COAL FIELD AND SEAMS.

(1) My evidence refers principally to the western portion of the Carmarthenshire anthracite field, known as the Gwendraeth valley. The field is in some parts very much disturbed by rolls, squeezes, and wash-outs especially to the west of Pontyeates.

(2) The first seam of a workable quality is the Carway, which is worked at Gwendraeth Colliery a little to the west of Pontyeates. It is 3ft. 6in. thick, and I believe it proves very well. It has been proved at several places on the crop.

(3) The Big or 9ft. Seam, which is about 1,750ft. vertically below the Carway, varies in thickness from 6ft. to 12ft. or 13ft., but the average can be taken at about 7½ft. This seam is at present worked by the Great Mountain Colliery Co., Pontyberem Collieries, and Trimsaran. It was formerly worked at Carway, to the east of Trimsaran. This seam is subject to squeezes and wash-outs; in the western portion of the Pontyberem taking there is an area (as far as at present known) of about 200 acres, where the seam is completely washed out, the bottom stone following its regular course. Then on the western side of Pontyberem, taking (over boundary), under "Pentre Mawr," the coal was again found in its thickness for about 20 chains, level course, and then a fault was met with, the thickness of which has not been proved. To the west of this the Big Vein has not been proved until you get down to Carway, a distance of over three miles to the west. Trial pits have been put down, but nothing bigger than about 3ft. thick has been proved, which is supposed to be the Big Vein.

(4) The Green Seam averages from 2ft. 8in. clean coal with black rashes and clod on top, and lies vertically eight yards below the Big Vein, and is also worked at Great Mountain, Pontyberem, and at a small colliery at Pontyeates. It was formerly worked at Carway and also Trimsaran. The same remarks as to the wash-out in the Big Seam at Pontyberem apply, and this seam also is found to the west again.

(5) Ddugaled Seam is from 2ft. 10in. to 3ft. in thickness, and is 32 yards vertically below the Green Seam. This seam has been worked on the crop and for some distance down at Pontyberem, and also to the west by the Pentre Mawr Co. At present it is not worked anywhere in the valley. As far as proved, it is not affected by the aforementioned wash-out.

(6) Stanllyd Seam lies 16 yards below Ddugaled Seam, It is called the Big Seam in collieries east of Crosshands. Coming west of Crosshands it has proved very irregular both in thickness and quality, with, as a rule, a very bad top, there being sometimes 8ft. to 9ft. of black rashing on the top, which runs through the smallest holes. It is not at present worked anywhere west of Crosshands. At Pontyberem Collieries it has been driven to in several places, but so far it has not proved workable; I may say however that at a depth down the slant of 1,100 yards we have driven into it, and have met with a very good piece of coal 4ft. thick, with a fair top, and it is intended to test it further.

(7) Crasucha Seam is from 2ft. 9in. to 3ft. in thickness, and lies 10 yards vertically below Stanllyd Seam. It is worked by the Great Mountain Company, and at Pontyberem. It is of very good quality, with good top, and is not affected by the wash-out in the upper seams.

(8) Crasissa Seam is given in many sections as being 3ft. to 3ft. 6in. thick, but I have never seen it, nor can I find where it has been proved. All I have seen is a few inches of coal about 17 yards below Crasucha.

(9) Breslyd, sometimes called the Charcoal Seam, lies 31 yards below Crasissa, and is about 2ft. 6in. to 2ft. 8in. thick, is of good quality, with hard top, and has been worked at Pontyberem in the old pits. The next place, I believe, where it is now being worked is at Ponthenry Colliery.

(10) Gwendreath Seam lies 28 yards below Breslyd, and is about 3ft. thick. It is being worked at Capel Ifan Colliery, and also at Ponthenry. It proves very well in both these places. It was also worked for some distance on the crop at Pontyeates. It is a clean coal; top varies, it is sometimes very good, and at other times there are quantities of clod on top.

(11) Triquart Seam, about 2ft. thick, lies 26 yards below Gwendraeth. This is not worked anywhere to the west of Crosshands—where I believe they work it. It has in the past been worked on the crop between here and Crosshands.

(12) Little Seam, 1ft. 6in. thick, lies 38 yards below Triquart Seam. This is not worked anywhere.

(13) Lower Pumpquart Seam. This seam is worked at Crosshands and Pontyberem. Formerly it was worked at Capel Ifan Colliery by Messrs. Elkington, but it did not turn out well. They were very much troubled by rolls, with consequent soft coal, and it was abandoned as being too expensive. Then from there to Pontyeates it has not been proved; at the latter place it was worked at Plasbach Colliery below Pontyeates, but for some reason it was stopped. I believe they had coal of fair quality at Crosshands. I believe the seam averages about 3ft. thick; at Pontyberem it averages 3ft. 9in. thick, clean coal, very good quality, and with rock top. The Pumpquart is about 10 yards below the Little Seam.

(14) Rhasfach Seam is about 1ft. 6in. thick, and lies about 18 yards below Pumpquart Seam. The only place where I know it to have been proved is below Pontyeates on the northern side of the valley. It has very good fireclay as bottom.

(15) The Pontyberem taking has only two faults running through it of any size, the largest being 50 yards upthrow to the east running on the eastern side of the taking nearly north and south, the other 16 yards upthrow west, which runs south-westerly. The most serious disturbances in the valley consist of rolls and wash-outs. This is especially so when you get below Pontyeates, and from there to Carway, a distance of about three miles. Several collieries have been opened in this portion of the district, and even now trials are being made, but with very little success.

(16) All the coals in this valley are on the north crop, with a dip of about 16°, varying in some places up to 45°, until they get down to a depth of about 1,100 yards on slant, when they flatten down to, in many cases, 6in. per yard.

MODE OF WORKING.

(17) In this valley all the collieries are won by slants, as the seams outcrop in the valley and dip to the south. with the surface rising to the south in parts very sharply, The Big Seam we work at Pontyberem, where the average dip of the seam is about 15°. The seam is worked by driving cross measures from the Green Seam, every 200 yards. By so doing, we keep our main roads in the Green Seam, cutting off the Big Seam every 200 yards. Ranges are turned from slants about every 140 yards east and west. Inclines are then driven to the full rise, and stalls turned off on each side of the incline about every 17 yards. When nearer the surface stalls were driven every 12 yards apart. The stalls (single) but driven about four to seven yards wide (according to top), and when in about 100 yards the pillars are brought back, or so much of them as possible. The top in many places is very tender and dangerous, and has to be all double-timbered to the face. The difficulty in attempting long-wall is that there is not sufficient rubbish to stow the stalls, so that a great many cogs would have to be put in, which would make the cost prohibitive.

The Green Seam is worked by long-wall. Inclines are driven to the full rise to the north, and stalls driven east and west every 18 yards—the whole of the coal being worked away. The coal is clean; there is no holing through it, but sometimes the rashing on the top enables men to hole, at other times it is too strong. Powder is used in getting this coal. The clod from the top of the coal, and also rubbish from ripping roads are sufficient to fill the whole of the goafs.

The Crasucha Seam is worked in a similar way to the

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Green Seam, by long-wall. There is no holing anywhere in this seam, the clod on top being strong and sufficient with the rubbish from the roads to fill the goaf. Powder is rarely used in getting this coal. The above three seams are worked at Pontyberem Slants.

Lower Pumpquart.—This seam is worked at Chynhebog Colliery on the same taking as the other seams. This seam is also worked by driving level course headings from the main slant, and then by inclines and stalls being driven about every 17 yards. The stalls are worked about 7 to 8 yards wide on the lower side of the roads, and pillars are brought back, very little being left. A great quantity of powder is used in getting this coal, there being no holing of any kind, and the top being a strong bastard rock. Therefore, there is very little rubbish for filling goafs, and consequently it is difficult to work long-wall. I have stated that inclines are driven for getting coal. These inclines are driven by endless chains with a platform at each stall, and a pair of moveable rails for bridging over the platform, the full tram going down bringing up the empty one to the same platform, and so on in rotation.

(18) The quantity of small coal left behind varies considerably, and it is very difficult to give a reliable opinion, but from my observations I consider that an average of about 15 per cent. is left in workings. I may say that during the last few years the collier has sent out more small coal mixed with the large than he did formerly. Where the clod and road rubbish completely fill the goaf the men are allowed to fill small coal by itself, for which they are paid 6d. per ton, and if the coal is soft they fill through coal, but we do not encourage this, as generally this small when sent out is very dirty on account of rashings and clod getting mixed with it, making it practically worthless. Even the clean small made by breakers in manufacturing nuts is a drug on the market, there being at different collieries thousands of tons thrown on the banks. The quantity of small coal made might be lessened if work was more regular, that is, fewer holidays with the consequent after loss, and if we could get the colliers to attend more regularly at work. When a face of coal stands for days it must increase the quantity of small in faces, also it is very difficult to keep faces of long-wall straight, as you have some men constantly attending to their work, and a few who are constantly losing work. As a consequence one stall gets ahead of another, causing ribs and corners to be formed, which means an extra quantity of small coal.

(19) In estimating the yield of coal per acre after allowing for all losses, I take it that what is required is the average of the district. In some seams the quantity will be much less than in others. For instance, in the Big Seam the average would not, I think, work out at more than from 500 to 600 tons per foot thick per acre. In the other seams of smaller size (thickness), I think it will average 1,200 tons per foot thick per acre.

(20) In this neighbourhood I know of no coal lost through fires or floods, but pillars have often to be left against old crop workings to prevent water following the workings to the deep; but I do not consider that, as a general rule, this coal can be considered as lost, as if adequate pillars are left most of it might be got at the close of the colliery's life. Where pillars are left, unless sufficiently large, great loss is occasioned by squeeze. I do not think the quality deteriorates greatly by exposure to atmosphere.

(21) In the anthracite coalfield very little holing is done in coal, the work being mostly done by powder.

(22) It is not unusual in this district to leave barriers between properties, nor do I think where several properties are held by the same company that it should be so, as it tends to unnecessary loss of coal, and also interferes with the proper working of the colliery, especially in a district where there are may different owners.

(23) Barriers round colliery takings should certainly be kept, to prevent flooding from adjacent mines, and should, in my opinion, be not less than from 20 to 40 yards, varying according to depth and nature of coal and strata. In this district I know of no coal being left to form roof or floor.

(24) As to any portions of coal now left being worked again, I fear that those portions left as barriers between different colliery takings will, in most instances, be unworkable in future through the cost that would be required to get at them; the quantity and position of the coal would not justify the expenditure.

(25) As to the economical effect of an arrangement between employers and workmen as to leaving small coal in workings or paying for bringing it out, I fear, speaking of the anthracite district, that some other uses must be found for the consumption of small coal before any such arrangement could be made.

(26) The washing of coal in this district is vrey seldom adopted. In a great many cases there is no water available unless by pumping, and the water raised from the mine is often unfit for the purpose, not being clean enough, more especially where it has sulphate of iron in it, which is often the case. Most collieries in this district have now erected coal-breakers, with revolving or jigging screens for sorting different sized nuts and peas. Indeed, the larger proportion of the colliery owners in this district break all their coal into nuts.

(27) As to inaccurate plans, no doubt in times past plans were kept in many cases inaccurately, but I think that at present this is not the case. I cannot give any glaring instances of such inaccuracies in my own experience.

(28) I do not think that many cases occur where pillars are left because of the want of rubbish for stowing and packing—that is, where rubbish is available, and the position is such that the rubbish can be taken to such places; but in pitched seams this is often impossible.

(29) I do not think that small coal that has been left underground can ever again be utilised, first, because it would be too expensive to get at, and secondly, because it is too much mixed with rubbish.

(30) I know of no leases which have covenants and obligations as to the mode of working, either in descending or ascending order. The clause which is generally inserted is: "The property shall be worked after the most approved plan usually worked in the district." As a rule the seams that appear best and most easily worked, are the first won. I think it would be better if the lower were worked first of all, but companies often have not the money to do this.

(31) I do not know of any restrictions in leases affecting the most economical working of coal, or preventing one from obtaining the largest possible marketable value.

(32) As to coal left to support buildings, or other surface arrangements, I think that the amount so left in this district is very small indeed, not worth consideration.

16216. Do you think any more coal can be got out of the mines that you are acquainted with by getting more small stuff out, or anything of that sort?—No, I do not think so. In some of the seams which we are working now at the present time long-wall we have to send the small coal out, or it comes to either doing one thing or the other, sending the small coal out or sending rubbish out, and, therefore, in those seams there is next to no small coal left behind.

16217. In your opinion there is no more small left behind than there ought to be?—No.

16218. And it would not pay to get out what is now left behind?—No; it is too mixed with dirt.

16219. That is your opinion?—Yes. As the last witness, Mr. Fisher, stated, it is the clod coming down mixed with the coal which makes it unprofitable to send the small out. Besides, consider the quantity we do bring out now: we have thousands of tons on the bank lying there perfectly useless, and we cannot sell it.

16220. (*Dr. Le Neve Foster.*) You have heaps of anthracite refuse at the surface?—Yes, small coal.

16221. But anthracite coal?—Yes.

16222. Have attempts been made to utilise it?—Yes.

16223. Unsuccessfully?—Unsuccessfully so far. I may say there is a certain amount—it has been already mentioned—of anthracite small, that is the small made from breaking the coal, which is being used at the present time for patent fuel, but only a small quantity, and that is, as mentioned, used by the Navy.

16224. (*Sir William Lewis.*) That is pure coal?—Yes, pure coal from the breakers. The other stuff is small, sent up by the colliers, and for it we have no market. It would not do for patent fuel.

16225. (*Professor Hull.*) Would it not do to make into briquettes?—No, it would not do to make into briquettes; it is not clean enough. Of course you may wash it, but it is not every colliery that has facilities. It is difficult to get water in some cases to wash coal.

16226. (*Dr. Le Nevè Foster.*) If you had an abundant supply of water, would it pay you to wash it?—Well, I

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Mr. Thomas Seymour.

18 June 1903.

doubt whether it would at the prices that we get for it afterwards. It would cost us over 1s. a ton to wash it.

16227. What could you sell it for?—I doubt whether you could sell the small to which I refer for more than 3s. or 4s. a ton.

16228. What size would that be?—The greater part of it is dust really.

16229. Similar to what we have in that sample produced by Mr. Roberts?—Yes.

16230. (*Sir William Lewis.*) You have nothing further to add to what Mr. Roberts, Mr. Davies, and Mr. Fisher have said with regard to the anthracite district?—No, except this matter which Mr. Roberts referred to as a "Court." After hearing what he said, I do not altogether agree with him. I think we have at the present time, if I may say so, sufficient courts of all kinds to look after us without creating any more.

16231. I am not surprised at your answer. That is your opinion?—Yes.

TWENTY-EIGHTH DAY.

Wednesday, 5th August 1903.

PRESENT:

The CHAIRMAN.

Sir WILLIAM LEWIS.
Mr. BRACE.
Mr. BRIGGS.
Professor DIXON.
Professor HULL

Mr. MACLAY.
Mr. SOPWITH.
Mr. TEALL.
Mr. YOUNG.

The SECRETARY.
The ASSISTANT SECRETARY.

Mr. JOHN G. HUDSON, called; and Examined.

Mr. John G. Hudson.

5 Aug. 1903.

NOTES ON THE PROBABLE FURTHER IMPROVEMENTS IN THE ECONOMY OF STEAM ENGINES.

16232. It is understood that the term "steam engine" includes the whole steam plant, that is the boiler, and the superheater and economiser if any, in addition to the engine proper.

The first step in this inquiry is to ascertain the margin that theoretically exists for further improvements between the results obtained by the best engines of the present day, and those that are possible from a perfect plant. A Committee of the Institution of Civil Engineers on "the thermal efficiency of steam engines," a few years ago decided upon such an ideal engine to serve as a standard of comparison for actual engines. This ideal engine was assumed to utilise the whole of the heat theoretically available under the conditions of working, and to be free from the imperfections and losses which must necessarily occur in an actual engine. Even this perfect ideal engine is very far from being able to utilise the whole of the heat furnished to it in the steam, and convert the same into power, the possible return even under the most favourable conditions being about 30 per cent., the bulk of the balance being unavoidably lost in the exhaust steam discharged from the engine, except a comparatively small portion lost in the chimney gases. Of this 30 per cent. which is all that can be theoretically realised by the ideal engine, about one-half, or 15 per cent. has been realised by the best actual engine, so that the total margin for improvement in the present engine is represented by a reduction of the fuel required, to one-half. To obtain this reduction the actual engine must be made to resemble the ideal one, so as to lose no heat by radiation; it must be free from friction, must have no clearances in the cylinder, and a number of other similar qualities which are absolutely unattainable in practice in the present state of knowledge, though they are not barred by any natural laws. It would therefore appear that no very considerable proportion of this theoretical possible saving is likely to be attained in practice.

The improved economy of steam engines, which has been going on steadily for many years, may be ascribed to improved design, to increase in steam pressures and, in more recent years, to superheating. Any further marked improvement due to a further increase in steam pressure can hardly be looked for, the further possible gain by this means being small, whilst the accompanying disadvantages, such as the reduced efficiency of the boiler due to increased loss by radiation and otherwise, become more and more marked. In like manner, as regards superheating, the temperatures already reached approach, if they do not exceed, those to which the materials now used for the working parts of cylinders, pistons, valves, etc., can prudently be exposed, so that but little more improvement can be looked for under this head. There only remains improvement in design, which can hardly be expected to secure any marked improvement over the best results obtained, but may fairly be looked to to make such results more easily approached in everyday practice, though it must be borne in mind that even to secure this approach requires not only that the conditions should be favourable, but a very large amount of personal care and constant supervision, which the owner is rarely able to afford or willing to pay for. Greater stress is generally laid on securing certainty of continuous running without accidental stoppages, accompanied by steady or even turning, with a fair measure of economy. It may fairly be argued that such a view is commercially correct, with fuel at the comparatively low value generally obtaining in this country; in other words that a maximum steam economy may not justify the original extra outlay and constant extra care needed to obtain it.

By far the greatest loss from either an ideally perfect or an actual steam engine, is that of the heat necessarily and unavoidably contained in the exhaust steam, and lost when same is either discharged into the atmosphere or spent in heating up condensing water, the heat so wasted representing about 60 per cent. of the potential heat in the fuel. In some cases, and to a greater extent in America than this country, this heat is used for drying or heating purposes, and where this can be done a very great economy results. But it is quite common to find this source of economy neglected, the steam from an engine being condensed in order to secure the comparatively small advantage due to a vacuum being obtained, whilst steam is taken direct from the boiler for heating purposes.

Although hardly coming, strictly speaking, under the head of an improvement to the steam engine, attention may be drawn to what is known as the "waste heat engine." This is an adjunct to a steam engine consisting of an engine designed to use as its working fluid a liquid vapourising at a low temperature, and using the exhaust steam from the engine as the source of heat. There is no

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reason to doubt, and it has indeed been shown practically, that by such means a considerable economy may be obtained, but the process involves a good deal of additional and more or less delicate plant, an ample supply of condensing water at a low temperature, as well as practical difficulties in the working, and for these reasons is not likely in its present form to come into extended use.

Summing up, in view of the foregoing circumstances, whilst small improvements in detail will no doubt continue to be made, there does not seem to be any justification for anticipating any marked improvement on the best results hitherto recorded, but it may reasonably be hoped that improvements in design and detail will enable such results to be more easily, and therefore more generally, approached in everyday practice, particularly in the case of steam plants of sufficient magnitude to justify the necessary attention to good design and subsequent attention.

16232.*(*Chairman.*) Will you kindly state your qualifications ?—I am a member of the Institution of Civil Engineers and a member of the Institution of Mechanical Engineers; I am also a Director and Chief Engineer of Messrs. Hick, Hargreaves and Co., Bolton. I do not know whether I have succeeded in my notes in rightly interpreting the class of information you wish from us.

16233. Shortly stated, perhaps, it might be put in this way: Among the questions referred to us is that of possible economy; it naturally follows that the question as to whether we are ever going, by reason of a better class of engine or new methods, to obtain power with a less expenditure of coal, is obviously one of the subjects to be considered ?—Yes, I have rightly interpreted your question. You do not refer to any minute saving, but to something which will make a real difference in the amount of coal used, I take it.

16234. Something which will be an appreciable saving of our coal resources, or an addition to them ?—I have replied, I think, to that question in the notes of my evidence. If you wish I will give it to you very shortly.

16235. Your firm is well known as makers of steam engines with a great reputation; that we all understand ?—Thank you for saying so; I think we may fairly say it is so. It is a very old firm. The engines we make are mostly large engines, mostly on an important scale for big factories and so on, and of course we see the better class of engines. Those engines are mostly on a big enough scale for people to be careful about the consumption of coal, and to get a good thing.

16236. In speaking of a steam engine, would you include within that definition what I will call the plant and the boiler ?—The whole plant; I have interpreted your question in that light.

16237. Will you tell us, if you can, what is about the percentage of power which is obtained out of the coal by the steam engine at present ?—Starting with the amount of heat which is theoretically contained in the coal, if you could burn it perfectly with no excess of air and with no loss of radiation, and so on, we actually get somewhere about 15 per cent. only; but with a perfect engine working under like conditions you could only obtain some 30 per cent., so that we are really getting one half of all that by the laws of Nature we could hope to get.

16238. Really, putting the proposition in that way, the possibilities would only be to save half ?—Yes, exactly. Now to get that half back you must have an engine which has the qualifications of a perfect engine. I am speaking now of the steam plant in using the word "engine."

16239. Quite so ?—You must have no loss by radiation from the boiler; you must have perfect combustion; you must let in no more air to your furnaces than is actually necessary chemically and theoretically for pure combustion; you must have no loss from radiation by steam pipes; you must have your engine without friction; you must have your engine, above all, built of a non-conducting material.

16240. (*Sir William Lewis.*) Do you say without friction ?—Yes, if you are speaking of getting the heat into brake horse-power.

16241. (*Chairman.*) You are speaking now of what we may call the ideal engine ?—Yes, turning the actual heat from the coal into power given off by your engine. Now those things are absolutely impossible to get; we cannot get an engine without friction; we cannot get perfect combustion, we cannot avoid a certain amount of radiation, and, above all, we are obliged to build our engine pipes, etc., of a material which exchanges heat very freely, and therefore condenses steam and prevents its perfect working. Therefore, you see the chances of getting that half back are very small indeed. It takes an enormous amount of care at every point to get even that 15 per cent., the half of the 30 per cent. that is possible.

16242. I do not know whether I ought to ask this question or not, but is there any other plan of obtaining power ?—Do you mean to take me away from the steam engine proper ? I am speaking now of the common or garden steam engine, with a boiler, to get up steam by coal, with a steam pipe to take the steam, and a steam engine which is a reciprocating engine—a common or garden steam engine. I mention in my notes a steam engine which has come up of recent years, called the waste steam engine, which is very pretty indeed theoretically.

16243. (*Professor Dixon.*) What liquid are they using now ?—Some ether, an extremely volatile substance.

16244. Is it like petroleum ?—What they really use is, I think, bi-sulphide of carbon.

16245. Have you any of those in work ?—No. It is a German invention which has been tried on a reasonably large scale at one of the Universities or technical schools there. I think they have tried it in some electric station on the Continent.*

16246. It is actually in use at works ?—Yes.

16247. I know it has been tried in a technical school ?—It has been tried. I think they have an engine of 50 or 60 h.p.—something like that.

16248. Actually in work ?—Actually in work; but there are considerable difficulties with it. It is an extremely delicate thing, and the stuff is very awkward to keep in when you have it there.

16249. Have you any experience of that yourself ?—None. I have read about it carefully, that is all. The point about the great waste in steam engines is that you have to make your steam before you can use it, and when you have done with it you are obliged to let it go with a very large proportion of the heat in it. What we want to find is some way of utilising that heat, and that is where the crux of the whole thing is.

16250. (*Chairman.*) Would you say that even if it were possible to get what I will call the ideal engine, as you describe it, the economy in the consumption of coal would be somewhat modified by the increased cost of the machine?—Money will not do it. We have not the materials to make the perfect engine. You can take any one little point, and by extreme care and elaboration you can reduce the loss there by some very small fraction, and by doing that at every point you get to these best results; but you still do not get much beyond that 15 per cent. (or perhaps 15½ per cent.) which I have mentioned.

16251. Is a large engine relatively more economical than a small one, *qua* coal ?—No, not necessarily, except that with a large plant the inducement to make it economical and to look after it is so much greater. Some of the best results have been obtained with quite small engines.

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*With reference to the waste-heat engines which I mentioned, I was not at the time able to give the name of the experimenter. I now beg to say for the information of the Members of your Commission that the experiments were made by Professor E. Josse, and are detailed in a pamphlet issued by the Abwarmekraftmaschinen-Gesellschaft, M.B.H., (Waste Heat Engine Co., Ltd.), Berlin, N.W. Luisenstrasse, 29, from whom I have no doubt copies could be obtained. The experiments describe the test of a 60 to 70 h.p. engine on this principle at the Royal Technical High School at Berlin-Charlottenburg; also of an engine of 175 h.p. installed by the Berlin Electricity Station in May, 1901. The additional power claimed to have been realised by these engines appears to have been fully 30 per cent., or rather, that additional power is claimed to have been obtained by the partial utilisation of the heat contained in the exhaust steam.

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Mr. John G. Hudson.

5 Aug. 1903.

16252. The figures you have given us would represent the best results that would be obtained?—Yes, the best.

16253. That is from triple expansion, or any other expansion?—Well, they are figures which practically represent the best on record.

16254. With regard to the steam engine, is the principle of utilising the steam to a greater extent by means of more cylinders being extended?—No; the tendency is quite the other way. Ten years ago they were all talking of quadruple expansion and using triple; but now we have come back practically to compound engines—two stage compounds—with advantageous results. I am speaking now of land work; marine work is different; other conditions come in there, which make it different.

16255. Are the figures which you have given us the best figures that would be obtainable, for example, by means of one of the steam turbine engines?—Yes; I think they have not touched anything better than that. But the figures I have given you are obtained with superheat. The very best engine—I am speaking now of the engine proper, apart from the boiler—has touched 80 per cent. of the possible; but when you come to bring the boiler in with its losses, you come back to the 50 per cent. which I have mentioned in my notes. I was saying that the great loss, the inevitable loss, is in the steam exhausted from the engine. Now where you can utilise that steam in heating, you get your power for only the theoretical equivalent of the heat you use—the theoretical equivalent of the power—if you can find some uses for the exhaust steam. In a sugar refinery, for example, you utilise it absolutely; there is no waste whatever there.

16256. That is beyond the radiation?—Beyond the radiation; and, as I mentioned in my notes, I do not think nearly as much is done in the way of utilising exhaust steam as they do in other places, particularly the United States; there you quite commonly find a man with a pair of engines who will work in the winter one cylinder condensing and the other non-condensing, and who will utilise exhaust steam for heating his factory. I rarely find people do that here.

16257. They use more heat there in the winter time than they do here, do they not?—I think they do, but I cannot speak from experience.

16258. They heat their factories a good deal with it, I think?—That is done to a certain extent in this country by the exhaust steam.

16259. (*Professor Dixon.*) In chemical works the exhaust steam is used a good deal now, is it not?—I do not know. I have no experience, or very little, of chemical works. They use it wherever they have evaporation to do; they use it in alkali works and paper works.

16260. I know a good many works where they are utilising exhaust steam.—Yes.

16261. (*Chairman.*) Then I gather that in your view we need not anticipate any great saving or economy in the future as regards the consumption of coal from steam engines?—I am afraid that there is no prospect, so far as one can see—I do not wish to be arrogant—of appreciably improving on the best engines of the day. There is very great room for bringing up the rank and file to the same standard, if you can get people to give attention to it. I think the small engines are the great sinners—the users of small power where the cost of the fuel is not sufficiently important to justify any elaboration or any great care.

16262. Would you say that not more than 25 per cent. of the engines come up to the standard that you state?—No, I should not think anything like that.

16263. (*Professor Dixon.*) In your experience what is the average efficiency of the steam engines now in use in works and in mines in Great Britain?—I could not answer that question.

16264. Of course I do not want it accurately, but in your judgment?—When you speak of "efficiency," do you mean relatively to the heat that is actually in the coal if you could get it out, because that is a very important point to distinguish?

16265. I quite understand. Put it in which way you like?—You ask me to give an opinion of the efficiency of engines throughout the country, taking them all round?

16266. Yes; from your judgment and experience you have, no doubt, formed an idea?—It is only a guess; I should think 6 or 7 per cent. If you could only get up to 15 per cent. with the biggest engines, where great care is taken, I should think 6 or 7 per cent. would be a very liberal estimate when you consider all the thousand and one little engines without condensation, and no care used with regard to them.

16267. I am rather surprised that you put it so high?—It is only a guess.

16268. (*Mr. Sopwith.*) That would be for engines running pretty constantly?—My guess included all the engines.

16269. (*Professor Dixon.*) You refer to little upright engines and all sorts of things?—Yes; builders' crane engines, and so on, which are very wasteful as a rule.

16270. What extent has superheating reached in the best engines?—We supply superheaters almost as regularly as we supply boilers nowadays.

16271. How high do you put the temperature of the steam?—We have got up as far as 700°, but I generally get about 500° to 550°.

16272. Do you find that 700° acts on the valves?—I have not had 700° myself, but I have seen reports from engineers working in Russia and elsewhere, and they do not say so. No, the valves give no trouble whatever; but I have melted the white metal out of the metallic packings, and have had to put in a metal with a higher melting point. We found when we began that we could not keep the seats of the valve chests tight owing to difference of expansion, but the difficulties have been almost nominal.

16273. You now recommend something between 500° and 550° Fahr.?—Yes, about 550°; but you have not very much control over it. The way in which we like to put our superheaters is in the downtake flue of the boiler. When we began we used to put an arrangement for adjusting the superheat, but we found everybody wanted all they could get, and they never used those adjustments, and now we have ceased putting them in. There seems to be a fortunate correspondence between the two; if you put a superheater in the back flue of a Lancashire boiler you get just a nice heat, and it goes on without any trouble to anybody.

16274. You bring it back again?—Nearly all our customers use the Lancashire boilers, and the temperature at the back of the Lancashire boiler is anything from about 900° to 1,200° or 1,300° Fahr., which is just about the perfect temperature for using a superheater; it is not enough to injure the superheater, and it is enough to give you a reasonable degree of superheat. We find that with that we get roughly on the average 150° of superheat.

16275. And you have not found, as a matter of practice, that that wants more repair than the rest of the boiler?—No; it is simply astonishing how it stands; we have not worn out a superheater yet, and we have been making them for the last eight or nine years. They are made of very thick solid drawn steel tubes. I do not know whether you take any interest in these matters, but in case you should ask about them I brought a little pamphlet which you may like to see. (*Handing in the same.*)

16276. I suppose the steel soon gets acted upon on the surface?—No, that is the curious part about it; it does not.

16277. I mean so as to form a coating of oxide?—No, it does not seem to get acted upon at all.

16278. I do not mean worn away, but that a protecting coating is formed?—Well, the tubes get a kind of black gloss on them; I do not know whether it is the same as oxide.

16279. That is the same as "Barfing"?—Very likely it is.

16280. It is one way of doing it?—Exactly.

16281. So that I suppose the interior parts of your economisers get "Barfed" in that way?—I am afraid I cannot say; we have had so little trouble with them.

16282. You have not taken one down and examined the inside microscopically?—We have had them down-

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Perhaps we have had a half-dozen cases out of the whole where they have used extremely bad feed water, and have got one or two tubes stopped up, and then the outside has been burnt; but it has been very rare.

16283. The feed water in that case got into it?—Well, it had apparently a good deal of mineral in solution.

16284. That is what I was going to ask you; is there any priming with these superheaters?—Out of 700 we have certainly not had half-a-dozen cases.

16285. (*Chairman.*) Is the superheat taken through a coil in the flue?—At the back of the Lancashire boiler there is a tube plate placed level with the top of the seating, and from that hang a lot of tubes in the shape of hairpins, about 7 ft. long. In an ordinary boiler there are about 33 of them. It is very simple; the thing must be simple if it is going to be put in such a hot place.

16286. They are connected at the top and bottom, are they?—Yes; the steam goes up one way and down the other.

16287. That is really utilising waste heat, is it not?—No; you are taking the heat at an intermediate point.

16288. But is it not after it leaves the boiler?—No; well, it is after it leaves the flues of the boiler, but before it goes along the sides and bottom.

16289. You catch it the first time through, as it were?—You must catch it at the time when the temperature is right; you cannot have superheating with half cold gases; it is no use trying. You must have a good head of temperature to shove the heat through. The Lancashire boiler lends itself admirably to that; the back combustion chamber is exactly right.

16290. Then it catches the flame after it passes through the main flue before you split it?—Yes; after it goes through the actual furnace flues you catch it; then it goes along the bottom and back along the sides, and finally to the economiser.

16291. Does it not interfere with the draught?—Not appreciably. If a man has a bad draught he says he fancies it is the superheater, but that is all. We have not had any trouble. Independently fired superheaters are very often spoken of. The difficulty with those is, as I have just explained, that you must have a decently high temperature to do superheating, and when you have done superheating in an independently fired superheater you do not know what to do with the gases; you have to let them go away, and you lose so much heat with them that practically it neutralises all the advantages of superheating.

16292. (*Professor Dixon.*) Do you get any trouble with dust—coking on the superheater?—No. The only way in which you have trouble in that way is when you are using very small fuel with forced draught. You will get a big bank of very fine stuff in the back of the combustion chamber, and the tubes will get embedded in that: do you follow me?

16293. Yes. Have you got a sort of baffle plate that the draught goes against?—No. The whole of the back of the combustion chamber will get filled, 2 ft. to 2 ft. 6 in. in depth, with this fuel blowing forward. Now that means that it will get round about the bottom ends of the tubes of the superheater, and that will prevent them expanding freely, and they will distort; you must keep them short enough to be out of that, and if you keep them short so that they can hang freely, they keep quite straight.

16294. Otherwise this coke dust would protect them from the heat?—Otherwise the coke dust would prevent them expanding freely, and they would get distorted. Evidently the tubes get more or less plastic with the heat from time to time.

16295. (*Chairman.*) Of course, they would be colder at the bottom than at the top?—It is not so much that, as that the dust prevents their expanding freely.

16296. (*Professor Dixon.*) You mean that mass of coal would be so solid?—Yes.

16297. Is it the coal?—It is not the coal: it is the preventing of the expansion.

16298. (*Chairman.*) It is a purely mechanical operation?—Yes.

16299. (*Professor Dixon.*) In your experience has the increased efficiency in steam engines been accompanied by a decrease in the use of coal, or *vice versa*?—Do you mean, do we use less coal for a given output?

16300. No, I do not mean that: I mean, has the increased economy which has resulted from improvements in steam engines in any way resulted in a diminution in the total consumption of coal?—I am afraid I do not quite follow your question. Do you mean over the whole country?

16301. Yes.—For power purposes?

16302. Yes.—Unquestionably. If we take an old set of engines in hand we can certainly save a man as a rule from 30 to 33 per cent. of his coal consumption.

16303. No, I am not asking that.—I do not quite follow your question.

16304. You understand that we are reporting upon the time our coal supplies will last, amongst other things?—Yes.

16305. What I am asking you is, in your experience has the increased efficiency in the steam engine actually led to a diminution in the use of coal, or has the increased power which we are now using really increased the use of coal?—Now I follow. Well, that is beyond my scope.

16306. (*Sir William Lewis.*) Has it extended the application of steam engines?—I do not think I can say that it has. People will have the power if they want it, and they pay what is necessary.

16307. (*Chairman.*) But you would say that coincident with the period during which these economies have been made possible by the improvement of the steam engine, power has been applied to a great many more purposes?—Yes; I should say so, distinctly. I should think that has overtaken any saving.

16308. (*Professor Dixon.*) We know that more coal has been actually brought out of the mines: the amount has continually increased?—Yes. Well, those are big questions which are rather beyond me.

16309. (*Mr. Maclay.*) You referred to land engines only when you spoke of coming back from triple to compound engines?—I referred to land engines.

16310. What class of land engines?—My experience of recent years has been of large engines, almost all Corliss engines, for driving big factories—big jute mills in India, and cotton mills in India, Russia, and in this country, wherever people want big power. We build engines up to 3,000 or 4,000 h.p.: a very common size is 1,000 to 1,500 h.p.

16311. (*Chairman.*) Is the engine that is known as Willan and Robinson's a compound engine?—They build both compound and triple.

16312. (*Mr. Young.*) Do you think that you have any more reason for stating now that we are not likely to improve upon the 15 per cent. out of a possible 30 per cent. than you would have if you were speaking thirty or forty years ago about the possible economy then?—I quite see the gist of your question: you mean that I may be wrong, as people were then; but it seems to be a question of the laws of Nature at present. I do not think there is any room in the theories of the present day for any serious error, which theories go to show that with a steam engine working on the well-known lines of the present day—the same general principles of vapourising steam and using it in an engine—you cannot get back more than about 30 per cent. out of the heat of the coal: and even that assumes a perfect engine such as I have described; so that you can draw your own conclusions.

16313. Yes, but, taking the knowledge that engineers had at that time, would they not possibly have given the same answer as to the laws of Nature then?—I cannot say, of course, what their knowledge of the laws of Nature was, but I think philosophers all knew what power there was in steam: they also knew what difficulties there were to get over. They would at that time have said, "We cannot perhaps ever work at more than 10 lbs. pressure," but we now know that we can

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Mr. John G. Hudson.

5 Aug. 1903

work at any pressure, almost. We seem to have got to the limit where an increase of pressure will not help us.*

16314. (*Professor Dixon.*) You referred to the latent heat of steam, I think ?—Yes.

16315. You cannot possibly help that ?—No—that is the point. If you can find any way of using latent steam you will get over the difficulty.

16316. But you cannot use it for power ?—You cannot get the heat back.

16317. (*Mr. Briggs.*) With regard to what you said about going back to compound engines from triple, is it the fact that as regards economy alone you can do now as well or better with a compound engine than with a triple, or are you taking into account the fact that the engine is perhaps less expensive, and so on ?—I can do as well per brake horse-power with a good compound engine as I can with a triple.

16318. Therefore you prefer the simpler form ?—Yes, naturally. It costs a great deal less, and it is more efficient as a machine. If you take an interest in that point, I should like to mention why we are so often asked "Why do marine people all use triple or quadruple expansion engines when you say compound are the best ?" The reason is very simple: you see they will not put up with a complicated valve gear at sea; they will use common slide valves which cannot cut-off efficiently at less than a third to half stroke. It follows at once that in order to use steam at a high pressure and to get sufficient expansion you must increase the number of your cylinders—three if you like, or four if you like—when you are using very high pressure; but when you come to a land engine, it is permissible to use a very much more elaborate valve gear, and you can get any expansion you like in any number of cylinders, and people seem to have settled down to two as being quite enough for any engine, at any rate up to 2,000 h.p. There is another point: you have not a fly-wheel, and getting a larger number of cranks and more even turning is very valuable.

16319. Of course, you obviate the necessity for a fly-wheel in that ?—Yes: you do it more regularly—with a more uniform turning effort. We have hardly built any triple expansion engines now for a long time.

16320. Therefore, so far as the coal consumption goes, you are getting as good, if not a better, result out of your compound engines ?—There may possibly be a shade of difference. If the one object in life was to get the lowest coal consumption per indicated horse-power, I might perhaps go for the triple expansion engine, but if you take into account the friction of the engine, and come back to the question of getting at the brake horse-power, it turns on so small a point as this—the friction of the triple expansion engine of the ordinary kind is well on for once and a half, or twice, that of a good compound engine. The compound engine mechanically is a better machine.

16321. And with the comparatively low price of fuel in England it is not likely that any little extra economy would lead you back in that direction of over-elaborating your steam engine ?—No, I do not think so. It has been a matter of gradual growth. People who have had triple expansion engines have had a good deal of trouble with them, and they do not want another one: when they get another they get a compound engine. We have had a great number of cases like that.

16322. And as an incentive to small users of power to become more economical, I suppose you are not very hopeful that they will become so unless it is directly paying to them owing to the high price of coal ?—In the notes of my evidence I say that the hope you may have is that as designs improve you may more nearly approach the best results without requiring so much care on the part of the user. Just now to get the best results you must put the engine, or put the plant, in the hands of a man who takes an interest in it, and who will watch every point; the personal element comes in to an enormous extent.

16323. Do you think that the late high price of coal gave a considerable impetus to the improvement of the steam engine ?—I do not really think that it did. I do not think people as a rule take very much notice of it; a man who is in a big business using 1,000-h.p. has so many other interests of much greater magnitude. The best manufacturers that I know are those who do not want to go into their engine room; they want the thing to go right without having to bother about it; the man who is always fiddling about his engines and that sort of thing is not usually the successful manufacturer.

16324. (*Mr. Sopwith.*) In speaking of the 15 per cent. utilisation of the coal you are speaking of an engine which would be under trial, that is to say, during the time it is working ?—Oh, certainly.

16325. If that engine was working very intermittently the course of the consumption would not be the same ?—You would not get anything like that average, because, of course, if the engine was standing a sufficient length of time the whole of the heat would disappear in the radiation.

16326. Yes, quite so. Having in view the great number of engines which are working very intermittently, especially in collieries, the utilisation of the coal would, in all probability, be very considerably less than 6 or 7 per cent. When you speak of 6 or 7 per cent. you are comparing an engine actually at work also ?—Yes, I think so. Of course I only gave that as a very wild guess; it can only be a guess.

16327. I only wish to get at the 15 per cent. being the actual result of the engine as running ?—Yes. There is a great deal more loss than people realise in an engine working intermittently in that way. I do not think people realise at all what it takes to keep a boiler warm out of working hours at nights and at the week end. An ordinary Lancashire boiler will use somewhere about five tons of coal per week in that way.

6328. And that 15 per cent. will be very considerably reduced, even with the best engine, taking it all round ?—Yes, undoubtedly, if they are working it intermittently.

16329. And with other economical engines the amount would be considerably less ?—Well, it would not tell so considerably on an economical engine.

16330. But if you take a manufactory working from six to six o'clock, and even working double shifts, you get greater economy of coal than in the case of collieries and other works which form a very large proportion of the steam power users of the country. They work so intermittently that there would be a very much greater loss ?—Is not a colliery with winding engines and so on running continuously ?

16331. Well, they do in some places, but in others not; there is a great deal of intermittent running. With regard to the superheating, taking the 15 per cent. of the utilisation of the coal, and having the best results with regard to superheating, which you have put at, I think, about 550°, how much of that 15 per cent. do you put down to the superheater ?—The superheat, I should think, offhand, ought to make from 1½ to 2 per cent.

16332. I also understand you to say that there is very little trouble in using the superheated steam at that temperature ?—None, practically.

16333. Are you speaking of the average engine ?—No.

16334. Or a specially constructed engine ?—You could not use superheated steam with anything like that temperature on a slide valve engine.

16335. So that the great bulk of the engines which are in existence in the country at the present time would not be able to work with that amount of superheat ?—No, they would not.

16336. I understand you to say that limited superheating is of very little value.—No; the first few degrees of the superheat are the most valuable of all, in the sense that they give you dry steam instead of wet steam. Practically all boilers give wet steam more or less; it is only a question of how much.

* With reference to the soundness of the opinion I here expressed as to the small margin allowed by natural laws for the further improvement of the steam engine, I would venture to refer the Commission, if they are not already acquainted with it, to the very valuable report of a Committee of the Institution of Civil Engineers on "The Thermal Efficiency of Steam Engines," which gives at length the conclusions on the subject of the eminent engineers who formed the Committee. The report will be found in volume 134 of the Proceedings of the Institution.

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16337. Then if you take the ordinary engine and not a high-class engine adapted for superheating, and you superheat it slightly, you still would get a saving ?—You would make a very considerable saving, but you have to be careful not to overdo it.

16338. Because we had it suggested the other day that there was a sort of half measure in this superheating, that the boiler was covered in and the pipes were just taken over the top of the boiler and back again ?—I should not think that would help you much.

16339. Perhaps not, but whatever degree it is it would be of some assistance ?—The ordinary boilers, even the best, give wet steam ; it is only a question of how much. If you can dry that, then it is a very considerable gain.

16340. If a person takes an engine out and puts an engine down by which he is capable of utilising the heat given by the gases, he would save 2 per cent. ; you put it at that ?—No, he would save a great deal more than that.

16341. Would he save more than 2 per cent. ?—Yes, I should think so.

16342. I mean as far as the superheating is concerned ? —He would save more than that, because an engine of that sort would not be a high-class engine ; it would be an engine which was only getting some very small proportion of the possible efficiency. Speaking generally, the less economical the engine, the greater the saving to be effected by superheating.

16343. I see your point, but out of your improved engine the part of the saving that you put down for superheating would be 2 per cent. ?—It does not make pressure.

16344. It would make an economy in another way ?—You are speaking of taking a poor engine and utilising it by adding or applying superheat to it ?

16345. Yes ; I take it there would be very much greater economy all round ?—Yes.

16346. But of the economy that you would effect, 2 per cent. or 1½ per cent. would be due to superheat ?—No, because you are not up to that stage—in the very best engine superheating will represent about 2 per cent. These percentages are rather puzzling things. If you take the ordinary mill engine of a good class and put on a superheater you will improve the working of that engine by about 15 per cent.

16347. Altogether ?—Yes ; but then the unit we are beginning upon is totally different ; in the one case the 100 per cent. is the whole heat of the steam, and in the other cases the 100 per cent. is the fuel the engine is using.

16348. Then the answer you gave me first I think quite covers it ; that is, that roughly of that 15 per cent. in the perfect engine 2 per cent. was due to the superheating ?—Yes. quite so—somewhere about that.

16349. (*Sir William Lewis.*) With respect to what you have said about there being no advantage in the application of triple expansion in comparison with compound engines, have you had experience of the same class of engines which will enable you to say positively ?—Yes, we have of several—some very large ones. I have a number of factories under my notice which have triple expansion engines in them.

16350. And there is no advantage whatever over the use of compound engines ?—Opinion differs very greatly upon these points. English people, unfortunately, are not of that theoretical turn of mind that our Continental neighbours are, and they do not make tests. We have nothing like the number of tests to go by that the Continental people have. A man says, "I do not want the bother of testing ; the thing is running all right and I am satisfied :" and naturally we do not want to go and spend £200 or £300 in testing an engine ; we are only too glad to get rid of the engine and be done with it.

16351. My reason for asking the question is that I have had tests, and there is a difference in favour of the triple expansion with the same class of engines ?—But probably for every test you bring forward you would find another which would prove the opposite. I will give you an instance : We have an engine running in a mill where there are three cylinders in a row, working on a crank shaft ; one day something went wrong with the intermediate cylinder, and I said, "Take the valves out and work the thing compound, and leave out that intermediate cylinder." The customer was much pleased ; he said, "We are actually saving coal."

Mr. John G. Hudson.

5 Aug. 1903.

16352. Was that tried over a certain time, or was it while the thing was being repaired ?—I did not hear how long he kept it going like that ; I know he said he was so pleased that he would keep it going for a bit. I did not hear the sequel of it.

16353. He may have resorted to the triple afterwards ? —But look at it in this way ; there is a very large industry in India, the jute industry. Ten or 12 years ago they were putting in nothing but marine type engines—they had Corliss valve gear and an efficient valve gear ; those people now would not touch a triple expansion engine. Every engine that has been put in during the last few years has been compound horizontal ; they are simply sick of the vertical triple. In this industry the economy is defined by stating the weight of coal of a given quality used to produce a ton of cloth of a certain class, and in the Indian cotton mills to produce 1000 lbs. of yarn of a certain class. In each of these industries the record for economy is held by compound engines of our make.

16354. I am putting up the others now—triple expansion pumping engines.—Well, pumping engines are a special class ; they run all round the clock, and you probably have three cranks which will give you, I suppose, more even turning, which is a point of importance. But for factory work, well, the proof of the pudding is in the eating ; we have only made one triple expansion engine during about the last four years, I think, and that was in a case where some seven or eight years ago we put an engine of 1,600-h.p. into a mill. The people there do not know anything about engines ; they are building a new mill, and they say, "The old engine has done very well for us, and we will have another one like it," and they put in triple expansion. It is quite the unusual thing nowadays.

16355. Well, we are adopting the same course ; we are repeating that mistake, if it is a mistake ?—I am suggesting that your pumping engine is a special class of work ; there three cranks are very valuable, and you have not a big flywheel, probably. I do not know what class of pumping it is ; is it hydraulic pumping for town supply ?

16356. Yes—That is almost stereotyped, and you have not got the trip gear, probably—you have common slide valves.

16357. Yes—That is exactly what I was mentioning to one of the Commissioners before, that if you are going to have a common slide valve you must increase the number of your cylinders to deal with high pressure steam ; but you can deal with that steam equally well in two cylinders with trip gear.

16358. In answer to a question put by the Chairman, I think you indicated the very great difference between the best class of engine of the most modern type and the average engine that is now working throughout the kingdom ?—Yes.

16359. I do not know whether you have thought it over and formulated any estimate of the difference in the consumption of coal for engine purposes, assuming the whole of our engines were constructed upon the model type of the day ?—No, I have no statistics as to the number of engines working in this country, or of what type they are.

16360. But it would represent millions of tons ?—It would represent a very great deal. If you take a little builder's crane engine, or something of that sort, that is probably using 5 or 6 lbs. of coal per h.p.—perhaps more.

16361. (*Chairman.*) And it would be impracticable to use the other kind, would it not ?—Yes, to all intents and purposes ; to come back to the commercial point, it would not pay.

16362. You spoke about the temperature from superheating ; can you express the temperature in what is called pounds pressure ?—No, it does not affect the pressure.

16363. Would you not say 200 lbs. of steam is at a higher pressure than 100 lbs. ?—Yes, undoubtedly, but the superheating does not affect the pressure in the way it is used. If you were to take a closed vessel full

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Mr. John G. Hudson.

5 Aug. 1903.

of steam at a certain pressure, and you were to superheat it, you would increase the pressure, but in an ordinary engine that is not so; you make no increase of pressure.

16364. But the drier it is the more expansion you get out of it, do you not?—The superheating does not add materially to the theoretical advantage of the steam, but it adds greatly to the proportion of the theoretical value which you can get out. One of the great causes of loss in a steam engine is condensation, and by superheating the steam you are able to avoid a very large proportion of that condensation.

16365. What would be the temperature of steam in a locomotive engine which was working at 175 lbs. pressure?—Somewhere in the neighbourhood of 400° Fahr. There is a table in the book which I have handed in which gives it absolutely, if you will refer to it.

(*Professor Dixon.*) It is 377°.

16366. (*Chairman.*) Have you any knowledge as to whether what you describe as the loss from radiation in a locomotive steam engine is greater in a stationary engine?—I only know the locomotive engines by reading about them, and so on, but I should imagine, and I have heard it said, that there is a very considerable loss from radiation from cylinders, particularly outside cylinders, and that they are not as well closed as you might naturally expect they would be, seeing the way they have to rush through the air.

16367. (*Sir William Lewis.*) Although they are lagged?—As to that, I am not a locomotive engineer.

16368. (*Professor Dixon.*) Is there any advantage or any appreciable economy in the feed water? The point of my question is this, that if there is some difficulty in getting pure water, you will use less water with one of these superheaters?—Undoubtedly.

16369. And, therefore, some economy might come in in that way?—Well, it is a very small one.

16370. You think that is too small to count?—Yes.

16371. There would be some appreciable difference in the water used, would there not?—Unquestionably. You will find a table in the book I have handed in giving particulars furnished by a Continental engineer, with various degrees of superheat, and you will see at once how it advances. It is to be found in the little pamphlet.

16372. (*Chairman.*) Of course, that means a saving in coal?—Undoubtedly.

16373. (*Professor Dixon.*) But I was asking whether the actual water came into the accounts?—It is cutting it rather fine as to the question of saving in regard merely to the feed water.

16374. I was thinking of dealing with very hard or impure water, which you would have to purify?—You would undoubtedly save something.

16375. (*Chairman*). What is the action of the very high temperature upon the valves which you spoke about is it destructive?—I spoke of the difficulty of keeping the valve seats in.

16376. You did.—I am speaking now of stop valves, where you are in the habit of putting a bronze or gun-metal seating in the body; they become loose.

16377. With regard to the slide valves you spoke of, you said you could not use them?—No, there is a very great load on them, and they appear to come into metallic contact, and to tear one another.

16378. How is that overcome?—By using a class of valve which has not such an intensity of pressure on the face.

16379. How do you describe that?—The ordinary slide valve has an enormous area exposed, and the difference of pressure on it gives a great intensity of pressure per square inch upon the face. You may either use some form of equilibrium valve to reduce that—you may use a piston valve, for instance, or the Corliss valve, which we use, is an intermediate class, but good enough for that purpose, and very good in other respects.

16380. Then, according to your experience, the Corliss valve will work quite satisfactorily with temperature such as you have described?—We have not had a single instance out of many hundreds where it has given trouble. We have had one case where the piston gave trouble—only one.

16381. Does increase of pressure affect the valve, or is it merely the temperature?—As I was explaining, the superheat does not increase the pressure.

16382. That was not quite what I intended to ask?—Do you mean supposing you increase the pressure regardless of superheat, does that affect the valves?

16383. I will put it in another way; supposing you increase the pressure without superheating, and therefore without the high temperature to which you referred would that give trouble with the valves?—There would come a point when it would, undoubtedly. The higher you get the more ticklish it gets.

16384. But the difficulty comes mainly from the temperature, I gather from what you say?—With superheating?

16385. Yes.—The two together will undoubtedly act and react upon one another—that would increase the difficulty.

16386. (*Professor Dixon.*) Is it on account of any chemical action?—No, I think not.

16387. Or is it simply that they begin to rub?—It is purely mechanical, I think.

16388. Due greatly to the amount of surface?—To the metallic pressure on the surface bringing them into contact, I think. But I have had no trouble personally with our own engines; I have only heard of it.

16389. (*Mr. Sopwith.*) It may affect the lubrication of some engines?—You want to be careful as to what oil you use; it must be good oil. On the whole, I should say you slightly increase the amount of oil you must use, but not very greatly. Some of our customers who have put in superheaters have claimed that they use actually less oil than before superheating, but I should not like to state that, as a general result. I should say that with superheating you must use a certain amount of oil.

16390. And mineral oil?—It must be a purely mineral oil of a suitably high flash point.

Mr. Henry McLaren, called; and Examined.

Mr. Henry McLaren.

5 Aug. 1903.

16391. (*Chairman.*) You are a member of the firm of Messrs. J. and H. McLaren, of Leeds?—Yes.

Steam Engine Economy.

(1) All engineers are aware that the steam engine, at its best, is a very crude arrangement of converting heat into power. The following figures taken from an American Journal, entitled "Power," makes this fact very obvious.

There are few mill engines in this country working on as little as 2 lbs. of coal per indicated horse-power per hour. The figures given are based on a consumption of 2 lbs. of coal per indicated horse-power, each pound containing 13,500 British thermal units of heat; this is the calorific value of a good average coal.

The heat losses of a steam engine working under the above conditions are approximately:—

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	British Thermal Units.	Percentage of Total Heat in Coal.
Loss through grate bars	135	1·00
„ by radiation from boiler	675	5·00
„ in chimney gases	2,970	22·00
„ radiation from main steam pipes	210	1·56
„ „ „ auxiliary pipes	30	·22
„ in auxiliary engines' exhaust	190	1·40
„ radiation from engine	280	2·08
„ in engine exhaust	7 737	57·31
„ engine friction	76	·56
Total losses	12,303	91·13
Heat converted into brake horse power	1,197	8·87
Total heat in 1 lb. of coal	13,500	100·00

If this engine be used for driving an alternator generating electricity for power purposes there will be additional losses as follows :—

	British Thermal Units.	Percentage of Total Heat in the Coal.
Loss between furnace and engine	12,303	91·13
„ in electric generator	48	·36
„ in electric mains	115	·85
„ in transformer	52	·39
„ in motor	98	·73
Total losses	12,616	93·46
Power delivered to factory shafting	884	6·54
Total heat in 1 lb. of coal	13,500	100·00

8·87 per cent. of the total heat in the coal converted into power at the engine appears to be a very poor result; but if all condensing engines throughout the country did equally well, and the non-condensing engines in the same proportion, considerably over 50 per cent. of the engine fuel now used would be saved.

The further drop of 26 per cent. (i.e. from 8·87 to 6·54) between the engine and the factory shafting is not encouraging to advocates of central electric power stations, especially when interest, rates, etc., on the large amount of capital sunk in the mains is added.

(2) The question is, how can the coal of the country be saved? The answers I give are as follows :—

(A) Scrap all condensing steam engines and boilers not capable of converting 6 per cent. of the total heat of the coal used into power; this equals 3.2 lbs. per brake horse-power with coal containing 13,500 B.T.U. Scrap all non-condensing engines not capable of converting 4½ per cent. of the total heat in the coal used into power, equal to 4.2 lbs. coal per brake horse-power with coal containing 13,500 B.T.U. A good condensing engine working at 150 lbs. pressure should convert 10 per cent. of the heat into brake horse-power. A good non-condensing compound engine should convert 6 per cent. into brake horse-power.

(B) A very large saving can be effected by better management of steam engines and boilers. Condensing engines should show at least 25 per cent. better fuel economy than non-condensing engines of the same type, yet from recent investigations I have made in the coal consumption of 177 electric generating stations throughout the country, I find the non-condensing engines, on the average, beat the condensing in fuel economy by 13 per cent. Therefore 13 + 25 = 38 per cent. loss has to be accounted for by the condensing stations. A large proportion of this is due to bad arrangement of the plant and want of proper management.

(C) From the figures already given it will be observed that the largest loss of heat is in the exhaust steam. I anticipate that in the near future steam turbines will be driven by the exhaust steam from high-pressure engines. If the exhaust steam from a high-pressure engine be dried before entering the turbine great economy should result from this method of working, especially if the turbine exhausts into a good condenser. The engine would take the resilience out of the high-tension steam, the turbine taking the kinetic energy, which is at present lost. Experiments are at present being made in this direction.

(D) I anticipate that more use will be made of exhaust steam for heating buildings. In America there are companies who buy the exhaust steam from power plants in the large cities and distribute it for heating purposes. At the Yorkshire College, Leeds, we have the engines exhausting into the low-pressure mains for heating purposes, and at my firm's works in the winter time every unit of heat passing through the engine either goes for power or heating purposes. Exhaust steam can also be used for boiling where vacuum pans are used.

(E) I anticipate that more attention will be given to the loss of heat passing away in the chimney gases. At present fuel economisers are placed in the boiler flues;

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Mr. Henry McLaren.
5 Aug. 1903.

these are used for heating the feed-water by means of the waste heat, but if too much heat is abstracted the chimney draught is spoiled. This can be got over by using some system of mechanical draught, such as "Howden's" or "Elliss and Eaves'," now much used in marine practice. By means of fans, the air on its way to the furnace is passed through tubes surrounded by the waste gases leaving the economiser, thus cooling the gases to a much lower temperature than is permissible with natural draught.

(F) I anticipate considerable saving in coal by generating electric power with economical steam engines, and distributing it in bulk for lighting and tramways, also for driving machinery in shipyards, ironworks, mines, &c., and supplying users of small powers. But I do not anticipate that central power schemes will be able to supply mills and factories to compete with the ordinary mill engines of even moderate economy, generating the power on the spot, and driving direct on to the mill shafting.

16392. (*Chairman.*) You have come to tell us all about steam-engines, I understand?—I was requested to give my evidence on steam engines; therefore I have confined my remarks to steam engines, and I have not touched upon gas engines or methods of production of gaseous fuels from cheap coal, or that sort of thing. I thought perhaps you would have plenty of evidence upon those points. I can give you my opinions upon gas engines and their thermal economy. Of course, we quite understand they are more economical than steam engines in one way thermally; but these remarks are really confined to the steam engine, and when I say "steam engine," I mean the engine and boiler. Of course, seeing that it is coal we are dealing with, the boiler and its auxiliaries, and, in fact, the whole steam plant, must be considered together with the engine. In every case where "engine" is mentioned you must assume in taking the efficiencies that that is the steam plant as a whole. Another point is that these efficiencies, which seem very small to you, no doubt, are taken from the heat in the coal. As a rule, in taking efficiencies of a steam engine we take them from the heat in the steam, and in gas engines they are taken from the heat in the gas; the losses in generating the gas are not included. In this case in my figures here it is the actual heat in the fuel transformed into power—what we call brake horse-power; that is, including the friction of the engine—the actual power given off by the engine, not the indicated horse-power, which is only the power given off by the pistons.

16393. Could you tell us broadly what percentage you think the best class of steam-engine utilises of the power in the coal?—Of the heat in the coal; yes, I can give you that. The best class that we have made (and we have laid ourselves out for the manufacture of economical engines) is 12¾ per cent. of the total heat of the coal. A good condensing engine working at 150 lbs. pressure should convert 10 per cent. of the heat into brake horse-power; but we have done 12¾ per cent. (these are engines that have been tested by independent engineers), although, as a rule, we only guarantee 10½ per cent. for that type of engine, that is to say, a triple expansion condensing engine; 10½ per cent. is our guarantee, and our best test has been 12¾ per cent.

16394. (*Sir William Lewis.*) 10½ per cent. of the power in the coal?—10½ per cent. of the total heat in the coal, converted into work.

16395. (*Chairman.*) That looks like a very small percentage, does it not?—It is a very small percentage; but if all steam-engines did as well there would only be a fraction of the coal used that is used to-day for steam-engines.

16396. In speaking of 2 lbs. I see you speak of 2 lbs. of coal per indicated horse-power?—Yes; that is a very good result. Now these figures which I have been giving you, 12¾ per cent., mean 1¼ lbs. of coal per indicated horse-power. One and a quarter lbs. of coal per indicated horse-power is the best we have done in triple expansion engines; 2 lbs. is a very good economy, in fact it is vastly above the average of mill engines in this country to-day.

16397. (*Sir William Lewis.*) It is an enormous reduction in coal consumption, is it not; it is very much lower?—Yes, very much better than the usual type of what are considered economical engines. As I say, the steam-engine at its best is a very crude method of converting the heat into work. The gas-engine shows a higher thermal efficiency, but there are other things which I could mention that seem to bring it down in practice to almost worse than the steam-engine. For instance, take the Board of Trade returns for the consumption of fuel in electric lighting stations. I had occasion to go into that question, and I took the consumption at the whole of the stations in this country last year. There are only two stations wholly driven by gas-engines: Northwich was one, driven by Mond gas, and Redditch was another, driven by Dowson gas; and in both cases the ultimate cost of coal and cost of generating a unit of electricity was more than in the steam engine stations. I can find steam engine stations to beat the gas engine stations. That is in practice, but when we come to speak of the gas engine thermally it is nearly twice as good as the best steam engine.

16398. (*Chairman.*) Could you indicate what, in your opinion, is the explanation of the difference between practice and theory in that case?—The gas engine does not give as good mechanical efficiency as the steam engine; that is, if you get a high thermal efficiency per indicated h.p., that is on the piston, there is more friction loss. Of course the pistons in a large gas engine are nearly red hot when they are running. But even then their efficiency per brake horse-power, that is the power given off by the engine, is still much higher than in the case of a steam engine; so that that would not account for all of the loss. I have not followed the gas engine business very closely, but I am just giving you now the figures which I have here from the Board of Trade returns, showing that as yet the gas engine stations have rather disappointed their advocates. There is so much depending upon the management of the stations; there is the method of distributing the electricity, and a great many other things have to be taken into consideration.

16399. Quite so. When you spoke of cost, did you mean cost as expressed by the coal consumed or the cost of the coal?—By the cost of the coal in pence per unit.

16400. But was the cost of the coal about the same in the cases you have dealt with?—Well, I take Leigh, in Lancashire, as against Northwich in Cheshire, as being almost adjacent.

16401. The cost of the coal at the point of consumption would be about the same, would it?—I do not think it would, because they are using Mond gas at Northwich, and it is not every class of fuel that makes Mond gas satisfactorily. For instance, at the Farnley Ironworks at Leeds, they send to Worksop for coal to make their Mond gas; they find that pays them better than to use the slack of the district, which is a common coking coal, and they want a non-coking coal. It is the same, I believe, at Messrs. Mond's works; they get coal from a distance, and it may have been actually dearer than the coal at Leigh. But in these Board of Trade returns they do not give the quantity. If they would give the thermal units in the coal that they get for 1d. we should be able to make comparisons of the greatest nicety.

16402. In making your estimate of cost and your comparison of cost between the steam engine plant and the Mond gas plant, do you include the cost of the plants respectively?—No.

16403. Are you speaking merely from the point of view of coal cost?—No; I can give you what costs are included. The coal costs are put against coal costs, and in the case of the Mond Northwich plant it was 0·48d. per Board of Trade unit, and in the Leigh costs it was 0·4d. or 0·35d. The Redditch station, with the Dowson gas, was very much higher than the steam engines. There is another thing that I ought to mention with regard to Northwich gas; they buy their gas from the Mond Company and pay a high price for it, they do not generate it on the spot, but they pay 2d. per 1,000 cubic feet, buying it wholesale from Mond's works.

16404. Does that lessen or increase their costs?—I should think for a decent-sized station it would increase their costs; but for a small-sized station of about 104,000 units per annum I should say they could not make it any cheaper than 2d. per 1,000 cubic feet; they might be able to do so, but Mond gas plant does not lend itself to manufacturing in small quantities.

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16405. How does the Dowson gas in that case compare with Mond gas. You gave it as regards the steam?—I will give you my remarks on gas engines, which are very short. This is from a paper which I read lately (July, 1903) at the meeting of the Institution of Mechanical Engineers: "Gas engine stations: In the costs table of the *Electrical Times*, particulars are given of only two gas engine stations. Northwich, using Mond producer gas, has an output of 104,000 units. Its fuel cost is 0·48d. per unit, works costs are 1·48d. per unit." Now works costs include maintenance, water, oil, waste, stores, and everything else. Out of that 1·48d. total costs, 0·48d. is coal or fuel, so that there is 1d. for other charges, *i.e.*, 1·48d. represents the total cost.

16406. Including the coal?—Yes.

16407. That is per unit?—Per unit of electricity. "This is handsomely beaten by Leigh, a station with a larger output." It is a rather larger output, but it is as near the Northwich output as I could get—"using non-condensing steam engines"—they would be expected to be much higher seeing that they are non-condensing steam engines—"which comes out at 28 per cent. less in fuel and 15 per cent. less in works costs."

16408. (*Professor Dixon.*) Where is that?—At Leigh, as against Northwich.

16409. (*Chairman.*) You do not happen to know what the cost of coal at those places respectively was per ton?—I do not. I could, perhaps, find it. Of course, seeing that I was taking the whole of the stations in the country, they would not have given me the returns.

16410. Now will you tell us about the Dowson gas?—"Redditch, the other gas engine station, using Dowson producer gas (which of course they manufacture on the premises), has an output of over 172,000 units"—so that it is a larger station—the other was 104,000 units—"coal costs are 1·3d. per unit."

16411. (*Sir William Lewis.*) Coal alone?—Yes.

16412. (*Chairman.*) That is nearly three times as much as the other?—Yes.

16413. (*Mr. Sopwith.*) That is all anthracite?—Yes, it is expensive coal, and they have to bring it from South Wales. The works costs there are 2·61d. per unit, as compared with 1·48d. at Northwich. "There are over a dozen smaller-sized steam engine stations given in the Tables that beat these results" (of course in a year or two's time I think we shall see better results from gas engines); these are the only two stations wholly using gas engines. There are several stations using gas engines along with steam engines, but they do not keep the costs separate, and I could only get these two to compare.

16414. (*Chairman.*) But these costs per unit are high, are they not, compared with very large places?—They are not high compared with some of the London electric stations.

16415. (*Sir William Lewis.*) Take Glasgow?—Glasgow electric light is 0·36d. for fuel, and 0·95d. for works costs. These costs which I am giving you are not the final costs before delivering the current to the consumers.

16416. (*Chairman.*) That is to say, they do not include distribution?—They do not, nor interest on capital, management, etc.

16417. But it is the cost, as I understand, of the unit as registered at the works?—Yes, although not many of them meter it at the works as they send it out; it is like the case of a gas-works; if you go to a gas-works you can get 1,000 cubic feet of gas for 6d. if you take it away, but they will not distribute it for you at that price, and the distribution is a very important point.

16418. There is a "village" called Leeds, is there not?—Yes, that is a very good one; that is about the best, in regard to economy, in the country; that is 0·27d. per unit for fuel, and its works costs are 0·62d.

16419. That is about half of Northwich?—But they get coal very cheaply; they buy the coal in the coal pits round about, and they have the canal up to the works, and they buy the very poorest "smudge," as I think they call it in the district, and they find they get more thermal units for 1d. from that coal than from any other quality of coal. The manager is evidently a good man of business and knows when he is getting good value; he goes to a deal of trouble to burn this poor stuff. I do not think it is done so much by economy in the steam engine as by economy in buying the coal and working it economically.

16420. And they get plenty of boiler power?—Yes.

16421. (*Mr. Sopwith.*) What are the engines?—They are triple-expansion, some of them, and others are compound. They are mostly Bellis's; they are Bellis's, Fowler's, and our own in that station, but mostly Bellis's. That leads me up to this point. I have no doubt you have had a good deal of evidence upon central stations for generating power and distributing it. Central stations are very good in some cases, but in Glasgow they have a power-house for generating power for their tramways, which is one of the largest power-houses in the Kingdom, and their cost of generating a unit of electricity is 0·6d. delivered at their switch-board and metered at their board. Mr. Dickinson, the manager at Leeds, distributes it at the consumers' meters at 0·62d. So that Leeds beats the best central power-house in the Kingdom, so far as economy is concerned.

16422. (*Sir William Lewis.*) But in making these comparisons, do you not think it is necessary to take into account the actual cost of coal at each place?—It is very important. I mentioned that it is mostly from the economy in buying the coal that the Leeds cost is so low; I said it was not altogether due to their machinery.

16423. But in order to make any comparison you must assume a common price for the coal?—Certainly.

16424. Assuming a common price for the coal, what would you say as between Leeds and Glasgow?—I should say that the Glasgow Tramway power-house would show up better.

16425. (*Chairman.*) But would not Glasgow be cheaper for coal than Leeds?—No, I should not think so; of course, it would be interesting to know their price of coal; the Leeds people pay 4s. 6d. and 5s. for their slack, but when they cannot get the other stuff, and when the pits are working sufficiently well for them to get plenty of this very small stuff they prefer it as being better value. When they are burning their 4s. or 5s. slack I should think they are paying as much per ton as Glasgow.

16426. Yes, but their costs are still low?—Yes, and a lot of their time they have to use the better coal. This is for the whole year I am giving you now.

16427. (*Mr. Brace.*) Glasgow is as well situated for getting coal as Leeds would be, I think?—Yes, certainly.

16428. It is near to the coalfield?—Just as near. I should think it is a very fair comparison. There is nothing to prevent the Glasgow man using the same kind of stuff as the Leeds man.

16429. (*Chairman.*) The Leeds man utilises what would otherwise be waste of the colliery?—Yes, for which he pays perhaps 1s. 6d. or 1s. 9d., or 2s. per ton.

16430. (*Mr. Maclay.*) Where is the Table to which you have alluded to be found?—This is the "Electric Times," and it publishes the Board of Trade returns in a tabulated form.

16431. What is the date of it?—The 1st January of this year, taking the complete last year's returns. I may say the returns in the municipal stations are as a rule made up from the end of March, so that it would be from the end of March, 1901, to the end of March, 1902.

16432. (*Professor Dixon.*) To complete your comparison, would you tell us what power, and what type of gas-engine, was being used at Northwich and at Redditch respectively?—I could not give you the types.

16433. Could you tell us what power, for instance, is being used at Northwich?—I can give you the kilowatt power—the capacity in kilowatts.

16434. Is it a series of gas-engines or only one gas-engine?—It would be a series. There are 195 kilowatts. That is really a little over 250 h.p. that they would have installed altogether; but they would not have them all working.

16435. Would that be supplied by one engine or more? By several.

16436. Therefore it would be a small type of engine?—Yes, because they must have a stand-by; it would be a small type of engine.

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Mr. Henry McLaren.
5 Aug. 1903.

16437. Would there be two working at once or more?—Very likely there would be two working together with a stand-by to spare.

16438. Yes, they would be only about 100 h.p. engines?—I should say they would be certainly less than 100 h.p. engines, because there are difficulties that come in in the way of using larger engines; they would certainly work with a smaller engine in a small station of that size.

16439. But there would be more economy in working with a bigger engine, would there not?—Yes, I should certainly say so.

16440. (*Chairman.*) But the total power is only 200 h.p.?—Yes.

16441. Redditch is 175,000?—Yes, 175,000 output as against 104,000 of the other. At Redditch they have 335 kilowatts installed.

16442. Did I understand you to say that at one of these places they used anthracite coal?—Yes, at Redditch.

16443. Is that obtained in the neighbourhood?—No, it comes from South Wales.

16444. (*Sir William Lewis.*) You meant South Wales coal when you said "anthracite"?—Yes.

16445. (*Mr. Sopwith.*) That is for a Dowson gas producer?—Yes. I have mentioned that the Farnley people get their coal from Nottinghamshire.

16446. (*Mr. Briggs.*) That is for the Mond producer?—Yes.

16447. In the case of the Dowson I think it all comes from South Wales?—Yes.

16448. (*Chairman.*) Could you say whether you think the Commissioners have any justification for anticipating in the future any great economy of coal by means of steam-engines?—From figures already given, it will be observed that the largest loss of heat is in the exhaust steam. I anticipate that in the near future steam turbines will be driven by the exhaust.

16449. Do you mean as an auxiliary?—As an auxiliary—taking power out of the same heat. In a steam engine we can only expand it (to keep the engine within reasonable size) down to certain limits. The steam turbine, especially the "Delaval," works with a very low-pressure steam; in fact, they expand the steam before they put it through the turbine.

16450. After it leaves the boiler?—Yes. If they are working at 120 lbs. they expand it down to a fraction of 1 lb. before it really touches the wheel. All turbines are more or less glorified windmills, you might say; they receive their power from heat energy, converted into kinetic energy; it is the rush of the steam; wind would do as well if you could supply it for driving the turbines. There are experiments being made just now—especially by Rateau—to use the exhaust steam from a high pressure engine to drive the turbine and to generate electricity with that again, and I think there is every possibility that that will be successful. That is, if they can get the steam dry enough; the slightest amount of water through a turbine is apt to pull it up, by the friction of the water—the clearances are so small—but by just superheating or drying the exhaust steam from a steam-engine, they ought to be able to get a great economy by using it through a turbine after it leaves the engine on its way to the condenser.

16451. Would you, by the use in that way, get much above the 10 per cent. which you have already spoken of?—It ought to increase the efficiency say about 25 per cent.

16452. (*Sir William Lewis.*) Do you mean 25 per cent. of the 10 per cent?—Yes.

16453. That would be 12½ per cent.?—Yes, say 12½ per cent. I think it ought to get that. It is very difficult of course to prophesy, but from my own knowledge of steam engine working, I think that is the most promising idea.

16454. (*Chairman.*) But that is only giving the equivalent of what you would call the best engines. There are some engines, are there not, giving fully 12½ per cent.?—Of course, this engine that I gave you is 12¾ per cent., and putting that against the 10 per cent. engine in comparison, it would be 15 to 16 per cent.: that is taking the heat in the same way. I am bringing it now down to the actual heat, in the coal—12¾ per cent. + 25 per cent. of 12¾ per cent. = about 16 per cent.

16455. That is what I mean?—There are not many steam-engines working better than 12¾ per cent.—that is the heat in the coal—13 per cent. certainly would be the outside limit, and that method would increase the efficiency of the economical engine just as well as that of a less economical engine, because even the economical engine rejects a great quantity of heat in the exhaust steam; perhaps 50 per cent. of the total heat will be given out in exhaust steam.

16456. It goes back again to the point that, even with the steam turbine utilising what we will call for the purpose the waste heat or the loss of heat, which is the result of the exhaust steam, and acting as an auxiliary to the steam-engine and using high pressure, I presume you still do not get your total percentage much higher than 12½ per cent. or 13 per cent.?—Oh yes—that is, if you put it on to a 10 per cent. engine; but you must put it on to the best engine, so as to get 16 per cent. of the heat in the coal converted into power.

16457. (*Sir William Lewis.*) Then it would only be about 16 per cent.?—Yes. It would be under the thermal efficiency of a good gas engine then. A good gas engine that can give perhaps 20 or over 20 per cent. thermal efficiency will give 15 or 16 per cent. from actual coal. You must compare them all as regards actual coal; it is coal you are dealing with. That is what makes these percentages apparently so small. But most of the engines, of course, as you know, are using five and six times this amount. The most radical cure is, as I have suggested in my statement, to "scrap" these engines; a man is foolish to use a machine which is only turning out 50 per cent. of what it could do, but he is more than foolish to use an engine which loses him 50 per cent. in money, and uses an extra 50 per cent. of the resources of the country.

16458. (*Chairman.*) You have rather drastic remedies in mind with regard to a great many of the engines, have you not?—Yes. I think it is the most practical way of saving the coal.

16459. You would anticipate that in the future more use will be made of exhaust steam for heating buildings?—Yes.

16460. But that will not be a saving of coal?—It will not be saving it in the steam engine, but it will be saving the fuel in heating the building.

16461. (*Sir William Lewis.*) Would it not be a question of additional comfort rather than economy?—I may say, for instance, that at the Yorkshire College, we burn 1,100 tons per year in heating.

16462. (*Chairman.*) They are working under rather different conditions to those under which they would be working in a factory?—Yes. In our own works, for instance, in the winter time, every unit of heat which goes through our engine is utilised either in power or for heating purposes, and we do it by the exhaust steam; the installation is rather more expensive, but we save half a ton per day of fuel for heating purposes, which would otherwise be used if we had a coal fired heater.

16463. Yes, but if your engine is not running all night, you are deprived of the advantage at the very time when it is of value?—No, we have a bye-pass pipe, and we use it out of the boiler for keeping the heat up during the night with live steam. It is only during the day that the saving is effected.

16464. (*Sir William Lewis.*) It is a form of heating which is very commonly applied in America during the winter?—Yes—the exhaust steam.

16465. (*Chairman.*) I thought the practice in America now was to use heated air?—You can use heated air with the exhaust steam; you can put it through the heaters instead of heating with fire.

16466. Quite so, but they use heated air, do they not, to a very large extent?—Yes, to a very large extent, and it is a very convenient way.

16467. On the ground of ventilation, probably?—It is a very good method. We use that method because you get the ventilation, as you say.

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16468. Do you use that method in your works?—No, we work with radiators; but at the College we have heated air by exhaust steam from the engines. The leather department, is all heated in that manner.

16469. Do you anticipate that more attention will be given to the loss of heat passing away in the chimney gases. I see you put those figures rather high in your Table, do you not?—No.

16470. You put it at 22 per cent.?—22 per cent. is not an out of the way loss. If you deduct that 22 per cent. and the radiation from the boiler (that is 5 per cent), and the loss through the grate bars (that is 1 per cent.), that comes to 28 per cent; it leaves the efficiency of the boiler at 72 per cent. Do you follow me? The rest of the heat that has been put into the boiler goes to the engine in the shape of steam.

16471. Quite so, but the great loss is in the exhaust?—The great loss as you observe is in the exhaust; and that is naturally where you would look for some method of trapping the heat. I have here the report of the Commission which was appointed on water-tube boilers for the Navy, and it gives the losses in the various boilers which they tested. There were two war vessels and a Cunarder, and this Boiler Commission went to great trouble to thoroughly test them; they made balance sheets of the tests showing the heat units received, and how they were expended. The thermal efficiency is given here for the "Minerva" and the "Hyacinth" (those are the two war vessels), and for the "Saxonia," the Cunarder. I will give them all at the full power. The "Minerva" only gave a percentage of 61·4, as against that 72 per cent. I have given you; there was 38·6 per cent. lost in heat up the chimney, and in radiation, and one thing and another. That is in a war vessel which is supposed to be up-to-date. The "Hyacinth" did very much better —73·3 per cent., as against 61·4 per cent.

16472. Is there any obvious cause for that difference?—Well, I will give it to you. I may say I have brought these notes with me, because I mention in my statement especially that management has a great deal to do with the economy of steam plants; the management is to blame more than almost anything—more than the construction —because if you put the best engines in but have bad management, you very soon find poor results coming out. Here there is evidently mismanagement in the Navy also, because when the Boiler Commission, which was formed of leading engineers, was appointed, they made their preliminary tests, and they pointed out to the Admiralty the great loss which there was in efficiency in the boilers of the "Minerva," and they suggested that retarders should be put in the boiler tubes, in order to retard the draught from getting through so freely. That brought the percentage up from 61·4 to 68·4—just the very fact of putting little sheet-iron retarders into the boiler tubes to baffle the draught from getting through so clearly. This boat had been running for some years, so this was evidently a pure case of mismanagement on the part of the naval engineers; they ought to have known that they were losing that heat; so that there is a greater excuse for the ordinary steam user. There are many men getting 1½ and 2 per cent. out of their machines, who might be getting 10 per cent. if they really understood how to do it.

16473. Is there any simple and automatic method of recording what is being done?—There is now. Of course the way in which you can get at it is to analyse the gases, and also take the temperature of the escaping gases. By analysing them, you get the quantity of oxygen and air that is passing through, and you find that most of the heavy losses are due to excess of air. The best fireman is the man who can fire and let in the least quantity of surplus air. If we burn 1 lb. of ordinary Welsh coal—some is better than others, but take ordinary Welsh coal—it requires about 11½ lbs. of air to burn it; a man who uses, say, 23 or 24 lbs. has all that excess of air to heat up: and, seeing that there are perhaps 13 cubic feet to the lb., or something like that, he has a very large quantity of air that is doing the fire absolutely no good, but is being heated up, and going up the chimney and carrying off this heat.

16474. (*Sir William Lewis.*) You would advocate automatic stokers?—I advocate automatic stokers in certain conditions where your load is constant, but they are worse than hand-firing when you come to have a load which is varying. You cannot vary an automatic stoker sufficiently to keep the grates covered, and it is when the grate gets uncovered and cold air goes through that there is a great loss.

16475. Then there is great extravagance due to having fires too thick?—Yes: when you make carbonic-oxide, you can lose very much more than in excess of air. If you get the slightest percentage too little of air, you make carbonic oxide, and you lose your units to a most alarming degree.

16476. (*Chairman.*) Do you know the automatic recorder which records the quantity of carbonic acid?—I do not know it personally, but I know there is such a thing. We always work by analysing the gases in our tests. In these three vessels to which I am drawing your attention there is 61 per cent., 73 per cent., and in the Cunarder 82·3 per cent. efficiency of the boilers, so that Cunarder was working with a loss of 17·7.

16477. (*Sir William Lewis.*) Were these tests with the same description of coal?—With the same description of coal, and taking the heat units of the coal. So that if one has a better coal than the other due allowance is made for that. But I may say, on the other hand, that the "Saxonia" had a heated draught: they had tubes through the up-take from the boilers, and drew the cold air through those tubes and heated it up to 180° before it went into the furnace. That was a great saving: they saved about 4 per cent. But on the other hand through bad firing they lost in carbonic oxide by incomplete combustion just about as much as they saved by the heated air.

16478. (*Chairman.*) That was in the "Saxonia"?—Yes, but that is purely a case of bad firing. It is mentioned in the report, I think, that the firing was very indifferent on the "Saxonia."

16479. (*Mr. Brace.*) Speaking generally would the fault of indifferent firing be the fault of the workmen or of the engineers?—The fault of the stokers.

16480. Of course it is the engineers' duty to look after that?—Yes. The second engineer is told off to see that the boilers are worked in a proper manner. But there is an art in firing. I used to take part in firing competitions, and I quite appreciate the difficulties of sailing near the wind with regard to firing.

16481. (*Professor Dixon.*) Do they make gas analyses on board ship?—No, but this Commission did.

16482. Usually it is not done?—Usually it is not done. That is a point which I should like to mention, that nowadays there is no excuse for not making gas analyses and other tests: you can get young engineers who are fully competent to do that class of work for very little. I advocate that in a place such as a large power station there should in all cases be a man to do nothing else but make tests with a view to economy or stopping loss. They are taught very well at the technical colleges to do that class of work, and they can do it. It is a great luxury to older engineers to have those young fellows making such tests: I employ them myself. At Leeds Electric Light Works there is a man told off to do nothing else but look to those points. It is not all done at Leeds by the cheap coal.

16483. (*Chairman.*) Then, of course, the real value of that is, it tells you first that there is something wrong?—Yes, and you see where it is wrong. If you have to go, as it were, by instinct, you have to be actually doing the firing yourself, and you have to find out by trial and error what any educated engineer can tell you at once.

16484. Are you a believer in the system of mechanical draught?—Yes, inasmuch as you can get the draught and still abstract the heat from the waste gases. With natural draught if you abstract too much heat from your waste gases, of course it spoils your draught. Another great point in economical working and firing is not to have your grate area too large for the work you are doing, but you want it just so that you can nicely keep it covered, so as to generate the steam on the most economical lines. Then, when you come to want a little over-load, you are done if you have not mechanical draught, because immediately you try to fire harder you thicken the fire, and the draught fails as the resistance is greater. But when

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Mr. Henry McLaren.
5 Aug. 1903.

you have mechanical draught, you can turn it on and work with the same sized grate. When you are not working with mechanical draught you must have your grates arranged for the highest loads you have to work at: then when you are at lighter loads your fire is too thin.

16485. You are extravagant then?—Yes. Of course mechanical draught costs power to make it. I certainly should not advocate mechanical draught without heating the draught, for two reasons—you have the loss of the power required for the draught, and if you blow cold air through a boiler you are apt to set up strains, which are very detrimental to the boiler.

16486. Do you look upon a locomotive engine as having mechanical draught?—Yes. That is by exhaust steam, and that can be regulated in some locomotives by altering the blast nozzle; in others they can shut the dampers, and that prevents it getting through. I look upon the locomotive as a very efficient machine, considering the work it has to do: there is a large power put into a small space.

16487. But it gets very little out of the coal, does it not?—Well, the best tests I have seen have been 3 lbs. per horse-power per hour, as against 2 lbs. which I gave in these figures.

16488. Well, that is 50 per cent. more?—Yes, but the locomotive is non-condensing, and the 2 lbs. is for condensing engines.

16489. (*Sir William Lewis.*) That is very exceptional, is it not, where it is as low as 3 lbs.?—Yes; I have seen tests as low as 3 lbs.

16490. It is very exceptional with them as low as 3 lbs.?—These were good main line locomotives that were taken.

16491. (*Chairman.*) Were they compound?—No, they were the ordinary type. The railway practice with regard to compound locomotives is not on the right lines, according to my idea.

16492. I quite agree with you, but I want somebody to find out which is the best?—I was brought up in the marine trade, and certainly the railways do not follow the marine practice in compounds. As a rule, the port areas of their low pressure cylinders are very much too small. I had a lot of diagrams sent me from the Argentine for compound locomotives, which when they were running at 13 miles per hour were all right, but when they ran at 35 it took several hundreds of horse-power to pump the steam out of the low-pressure cylinder. If they had been designed by a man who was accustomed to designing compound engines, he certainly would not have made them in that way. But there is a great point to be considered in regard to compound locomotives: they have not the room—their limits of gauge prevent their doing things which they might otherwise do.

16493. But still, there are a good many being built on that system, are there not?—Yes, and they are getting better every day. I should not say that the compound will not be the locomotive of the future. I know that in traction engines, of which we make large numbers for export to the Colonies, New Zealand and those places, we cannot sell simple engines.

16494. Really, you have to compound for those, have you?—We use compound for those, and nothing else, I may say, for shipment to places where coals are dear. We do not push compounds—they have simply pushed themselves—the customers will not buy anything else, so that that is a proof, to my mind.

16495. Is that a question of less coal being used?—Yes; they are higher in cost.

16496. But they are more economical in regard to coal?—Yes.

16497. And where coal is dear, that is important?—Yes. In the colonies, for instance, they are used for threshing largely, and the man who owns the engine and threshing machine has to find his own coal, his own water, his own men, and everything. He goes to a farm and threshes out, and he knows more about economy than the man in this country who gets his coal from the farmer whom he goes to thresh for.

16498. Do you go in for triple?—In electric lighting engines, what we make are all triple.

16499. But in the case of traction engines, they are all compound?—Yes—what we send abroad.

16500. (*Mr. Maclay.*) Do you find that you can, with mechanical draught, use an inferior class of coal with much greater advantage?—You can get a better draught if you do so; but the better way of burning inferior fuel is to burn it thin on the bars, where a natural draught will do as well for you as a forced draught. If you get a very poor class of coal and fire thick you will have trouble with it. In the use of inferior coal you get the best results with thin firing where natural draught is used.

16501. It is contended by patentees that you get a great advantage from the use of mechanical draught?—Yes it is; but from my own experience of firing—and I was brought up as a lad on very inferior coal—I know that you can fire inferior coal with equal economy with natural draught, if you fire every minute or every minute and a half, or something like that.

16502. (*Mr. Briggs.*) That is to say, you have to be constantly throwing on very small quantities?—Yes. My father was a farmer, and had steam ploughs and other engines, and he got the coal for nothing from the landlord (a large coal owner), seeing it was the rubbish from the pits, and we had to do very heavy work with very inferior coal: that is where I got my first experience in firing engines with inferior coal, and my experience is that using a thin fire and firing often you can keep your fires freer from clinker, which is the main point. With inferior coal, if you get it thick you have to use the poker, and immediately you use a poker for breaking up the large crusts you begin to form clinker, and you have your fire clinkered up within an hour. A good fireman never uses the poker except just to level off his fire at the finish of a run; it should always be done by the fire shovel alone.

16503. (*Professor Hull.*) What do you mean by inferior coal, is it coal with a large percentage of ash?—Yes, small coal—duff; it has not necessarily a larger percentage of ash, but you make more ashes through the bars.

16504. That is round coal?—Yes. You can have as good small coal—smudge—as you can round coal if it is from the best coal. There is practically very little difference between the thermal efficiency of the slack and the best coal. In firing at a competition or anything like that you break your big coal; an expert would never think of using the coal in the large lumps: you break it into pieces the size of pigeon's eggs, to get the best results with it.

16505. (*Mr. Maclay.*) Is it not generally found that you have greater economy with mechanical draught than without?—Yes, certainly, for this reason, that in firing every minute or every half minute you open the fire door so often and there are huge volumes of air going through; but with the mechanical stoker, if you can work so as to keep the door shut, all the air has to go through the fire.

16506. (*Chairman.*) Do most of the mechanical stokers have arrangements by which the air drawn in is heated?—No, very few.

16507. But would not that help?—Yes, that would certainly help. That is what I advocate in the mechanical stokers. A great number of the mechanical stokers are mechanical in a way, but the man has to open the fire door every three minutes. At a large power station the other day I timed a fireman who was working with a mechanical stoker which was a very good one; but every three minutes on the average he had to open the door and push the fire back with his rake.

16508. Was that necessary?—It was absolutely necessary to maintain the steam; you cannot expect any piece of machinery to distribute the coal all over the bars with the same intelligence as a human being would do.

16509. Then those were not moving bars?—They were moving bars, but they were evidently not carrying it back fast enough; there is always a liability for the coal to land and cake at the front end of the bars, and it has to be pushed back. That to a great extent does away with the utility of the mechanical stokers in using poor fuels.

16510. Do you believe in the "Underfeed"?—Well, I have not had any experience of it.

16511. It is being tried, is it not?—Yes, I have seen it at work.

16512. Some advantages are claimed for it?—I have never had any special knowledge of its working. I should think there would be considerable trouble with the coal caking there if it is a coking coal.

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16513. (*Professor Dixon*). Is that Frisby's firer or one of those things?—I do not know the name of it. This one had a worm, and screwed the fuel up through the grates.

16514. That is where the coal is pushed in underneath?—Yes. One member of the Commission here asked if mechanical stoking was not more economical for poor fuels; no doubt it is.

16515. (*Chairman*). Because you open the doors less frequently?—Yes. You do not open them at all, except just to level the fire; nearly all the losses are through the excess of air.

There is another point I might mention. I have not dealt with superheating, but no doubt you have had evidence as to that. There is a certain amount of economy obtained from superheating. There is another economy that I anticipate, and it seems to have been discovered more by accident than by design. For the last few years an engineer in Westminster, Mr. Halpin, has been endeavouring to store up power. He calls it "Thermal Storage;" his idea is to store the heat in vessels alongside of the boiler in intimate connection with the boiler, so that the steam in the vessel is kept at the same pressure as the steam in the boiler. The water in the vessel is at the same temperature as the water in the boiler; when there comes to be a heavy call for steam, such as at an electric light station, getting up to the peak of the load, they can utilise this water by running it into the boiler instead of putting in cold feed, and if they do not evaporate it that water gives up an amount of steam. They found that by pumping the water into the separate vessel instead of pumping it direct into the boiler there was a manifest saving; in fact, they got percentages of 20 per cent. saving.

16516. How is it communicated from the vessel to the boiler?—Just by a pipe.

16517. Does it communicate itself?—Well they have a cock so that they can let it in as they like. Professor Unwin and one or two others have made experiments with this, and they obtained an economy of 20 per cent. in fuel, besides this storage. I cannot explain why it should be. Putting the water in the separate vessel and getting it up to the full temperature of the boiler before they introduce it into the evaporating part of the boiler seems to mkae a wonderful change. It is the same almost as the triple expansion engine or the compound engine compared with the simple engine—doing the whole of the work with one cylinder you get a poor economy: doing the same work expanding out of one cylinder into another you get a much better economy in the compound engine. Here in the generation of the steam they find that by putting the water into the vessel and getting it up to the full temperature it does not interfere with the evaporation of the water when it gets into the boiler.

16518. (*Sir William Lewis.*) But is it heated before it gets into the boiler?—It is heated from the boiler because there is a steam pipe in connection with this vessel.

16519. It is a kind of water jacket?—No, it is a hot reservoir at the side of the boiler.

16520. (*Chairman.*) But it is a closed vessel?—It is a closed vessel: if they put the water direct into the boiler itself they got no economy, but if instead of putting it direct into the boiler they put it into this storage vessel and then allow it to get thoroughly heated to the full temperature of the boiler, it does not lessen the heat of the boiler when it is admitted.

16521. It has a less effect on the heat of the boiler?—Quite so. The heat has to come out of the boiler in the first instance to do that, but heating it in a separate vessel seems to be a great economy. I look to that as an important saving; certainly I have seen the results of a test carried out by a man in whom I have the greatest confidence, and the saving is marvellous.

16522. But, putting it in a simple form, is it not practically enlarging your boiler space?—No, it has not that effect at all. This was shown at the Civil Engineer's Institution, I believe, a little while ago, with a little boiler with glass ends: a lime-light was put behind the boiler, and then they set the water boiling in the boiler and reflected it on to a screen of fifteen feet diameter. As long as there was no water going into the boiler you could see the bubbles rising up through the water, generating steam: if they put cold water into the boiler those bubbles went round and round in the water and they did not seem to rise to the top: they just looked like wool. If they took the hot water quite up to the high temperature of the water in the boiler and put it in, evaporation went on without interruption: I cannot explain why it is, but there is certainly a very considerable economy, and if I may say so it has been discovered by accident more than by design.

16523. (*Professor Dixon.*) How was the reservoir heated?—With steam from the boiler.

16524. Do you mean the waste heat from the steam?—No, the live steam.

16525. (*Mr. Briggs.*) It circulates in it?—It circulates in it and just keeps it at the temperature.

16526. It must pass through it?—No, the steam will heat up anything colder. It will bring it all to one heat.

16527. (*Mr. Sopwith.*) What is the size of this vessel in proportion to the boiler?—They have them of various sizes. The whole idea of the thing at first was simply as a reservoir of heat: it was not done with the idea of generating steam with less coal.

16528. (*Chairman.*) It does not check the action that is going on?—It lessens the work of the boiler. In Halpin's system they simply put in the latent heat required to convert the hot water into steam, 966 units at atmospheric pressure. That seems to be the solution of it.

16529. (*Mr. Briggs.*) You say you have found triple expansion engines the best for power stations?—Yes.

16530. Mr. Hudson, who has given evidence before you, stated that he had gone back, in his practice, to compound engines for mill engines?—We cannot sell the compound engines, we used to make compounds. At nearly all the electric light stations now there is nothing supplied but triple. We can get with the compound a horse power at 16 lbs of steam, with the triples we get a horse power with 12½ of steam.—(*Sir William Lewis.*) That is 75 per cent.

16531. (*Mr. Briggs.*) Not much more than 75 per cent. of the top quantity?—Yes, of the top quantity. These are figures that we have obtained in our own practice. The great point that advocates of compound engines made as against triples was, they said that triples would be economical at the full load, but if you come to work them at the lighter loads, they would be very uneconomical.

16532. By reason of friction?—Not only friction, but they say you would get too many expansions, you would be expanding the steam all to nonsense at the lighter loads. We were the first to start triples in electric lighting, we put in the engines at the Oxford Electric Lighting Co.'s works about thirteen years ago, and they were the first triple engines put in. We did not advocate them, we made them to go to the Argentine as a matter of fact, and things having gone wrong in the Argentine at that time, they were sold in this country, and they really have been the pioneers, and have brought the whole of the makers of electric light to the use of triple expansion engines, simply because of their economy.

16533. (*Chairman.*) Would you say that the continuous and steady load had some effect upon the economy derivable therefrom?—I was just going to say that at that time 32 lbs. of steam per kilowatt at full load was considered a very good result: we guaranteed 24 lbs. at quarter, half, three-quarters, and full load, to show that they did not fall off in economy at lighter loads. In some of our quarter load and half load tests especially we came out at less per indicated horse power than we did at the full load, but the proportion of loss is much more; that is to say, the engine has to be kept running — the mechanical efficiency of the engine is not the same if you are doing a small load as if you were doing a large load. But we gained so much in economy in the engine per indicated horse power that we could afford to lose a little in mechanical efficiency. So that it is all nonsense to say that the triple expansion engine does not give as good an efficiency at the lighter loads as the compound: that is, if it is built for the work; for instance, in the case of the marine engine, if I were building a triple I would make the proportions of cylinder ratio very much larger.

16534. (*Chairman.*) But you have the advantage there of the condensing, have you not?—Yes, we have that in the electric lighting as well. I am only speaking of condensing engines now. In the case of marine engines I would make the proportions between the high and low

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Mr. Henry McLaren.
5 Aug. 1903.

pressure cylinders very large, because those engines are always working at their full load. But in the case of engines for generating power for electric lighting or power purposes, where your load is sometimes small and sometimes large, we make the most economical proportion at perhaps five-eighths or three-quarters of the load, and we lose considerably at the highest load and lose a little at the lowest load. So that the most economical point for your engine is what your average load would be: that would be an uneconomical engine for marine purposes if it was always working at the highest power, and things must be designed with regard to what they have to do.

16535. If you take the case of a big mill, like the jute factories in India, or one of the big cotton mills in Russia, would you say that the triple expansion was of equal value for work of that kind?—Certainly. That brings me to the last point I make in my statement, where I say that I anticipate there will be a considerable saving in coal by generating power at a central station and distributing it. I discriminate in the use of that power between distributing it for lighting, tramways, and for driving machinery in ship yards or iron works (that is isolated machinery), or supplying users of small powers. But I do not anticipate that the Central Power Schemes will be able to supply mills or factories to compete with the ordinary mill engines of even moderate economy.

16536. Is that because of the cost of the distribution?—It is largely because of the cost of distribution: in fact, even if you give the central power station its fuel supply for nothing, it cannot compete. Take the Glasgow Power House, for instance, where the total costs at the works are 8d.—they are 6d. without management or anything like that, but about 8d. as the power leaves the works—their coal is only ·19d. per unit. Now before that power is distributed and sold to the consumer I do not see that it is possible for them to sell it at less than 1¼d. per unit. The cost of fuel is a very small item: it cannot compare with the loss caused by the drop in the cables: besides, there is the interest and depreciation. In the case of this typical engine which we have taken here, it gives off 8.87 of the total heat into power in the engine, but if we suppose that the engine is driving an alternator and generating electricity for power purposes, there would be the various drops. It comes actually to this, that when you get on to the mill shafting you have 6·5 per cent. as against 8·7 per cent.: the difference between those two is 26 per cent. Well, that is more than the Glasgow Power House pays for coal. Anyone, such as a colliery owner, using power from a central power station, after he finds what his costs run out at, if he has a few hundred horse power to generate, will generate it himself. Why should he get it from any central power station if he can generate it himself for much less money? But for people who are using small powers, where a man's wages for attending to the engine is a large item in the total cost, say in the case of 25 h.p., and where you have a little engine and a man looking after it, the man's wages may be more than the cost of the coal, and that is a case in which the Central Power Scheme will come in.

16537. He saves the outlay of capital, and he saves the current expenses?—Yes, and he has the handiness, which is certainly a point to be considered.

16538. And a supply which can be enlarged at any moment?—Yes, and which never fails. In my own works we have considered the matter very carefully. The Hunslett Engine Co. are over the way, and Mr. Campbell, the proprietor, is a great friend of mine: we discussed this question very closely as to whether he should drive the whole of his works from the town mains—from the central power: we indicated all his engines (he was very badly fitted up—he had several engines in various parts of the works), and found that it would be very much cheaper to go on to the town mains. He was using about 70 or 80 horse power. I then went into our own driving, but I found that it would cost us £200 or £300 per annum more than it was costing us then after allowing for depreciation and setting aside a Sinking Fund for renewing plant and every expense we could imagine; because about ten years ago we put in a new engine of an economical type, which brought our coal down 60 per cent at one whip. Of course if we had had at that time any electric power connected with that engine, the electricity would have got the credit of all the saving, whereas it was purely due to a better class of engine. Although I am a maker of engines for electric machinery and central power schemes, and although the more there are going on the better, I say that there is a great deal of what is stated about the great economy of generating electricity, and distributing power by means of electricity, that is all nonsense. You can make the saving anything you like: it just depends upon what you compare it with: if you compare it with an engine using 6lb. of coal per horse power, you get a good result, but if you have to compare it with what they are doing in Lancashire, it is another matter. I asked a Lancashire man the other day what was the best they were doing amongst the mill engines in Lancashire; he said they were driving 1,000 horse power for 56 hours per week at £20 worth of coal; that runs out under one-tenth of a penny per horse power per hour.

16539. That is very low, surely?—That is what the Central Power Schemes will have to compete against.

16540. (*Sir William Lewis.*) You might reduce it below that if you get the coal for nothing?—Well, the Central Power Scheme could not, because they lose more in transmission than the whole value of the coal, and they have to pay the interest on their mains, and I daresay the local authorities will ask them to pay rates for allowing their mains to go through the districts.

16541. One question with regard to gas engines. You say the thermal efficiency of the gas engine is far above even the very best steam engine?—Yes.

16542. From our point of view, merely with regard to the economy of coal, whether the gas engine is as good economically, or whether it competes in total cost favourably or not, it would certainly be a coal saver?—Yes.

16543. So that if the gas engine be improved and made more reliable, so as to take the place of steam engines to a considerable extent, we might really hope for a very considerable saving in the actual consumption of coal?—Yes, I think so. I am a steam engine man, but I cannot shut my eyes to the fact that the gas engine is to be the engine of the future. There are considerable difficulties with the larger engines. The smaller engines can run without jacketting their pistons with water: their radiation is larger, and they have jackets round the cylinders. But there are considerable difficulties to overcome before you get to the very large gas engine, *e.g.*, owing to their having to put water into the piston, which is a thing that is flying backwards and forwards, and therefore very awkward to deal with; but I have no doubt that the men who are engaged in the manufacture of the gas engine to-day will bring it to perfection. Thermally considered it is far and away ahead of the steam engine: but for reversing purposes and things like that, the steam engine cannot be beaten.

16544. That is to say for handiness?—For handiness and comfort in working. Another great point is the nuisance of gas engines in towns. We have two gas engines at the Yorkshire College, which have been the bane of my life; I have had the silencing of them to do. One is a very large one, and we are in a residential neighbourhood, and it is a most difficult thing to deal with, it took years to make it so that our neighbours could live alongside it.

16545. (*Professor Dixon.*) What gas were you burning there?—Town gas at 2*s.* 3*d.* per 1,000 cubic feet.

16546. (*Chairman.*) I thought this remedy of yours would have effectually done that.—What do you refer to may I ask?

16547. "Scrapping" them.—It would have done so; I advocated that, but I could not get the House Committee to go with me.

16548. (*Mr. Briggs.*) When gas engines are isolated, say for a small application of power, a small gas engine is infinitely more economical than taking steam to any distance is it not?—Certainly. I have much more faith in the distribution of gas in bulk and using it in gas engines than I have in the distribution of power by electricity from central stations.

16549. (*Chairman.*) Do you think the distribution costs less?—I think with Mond gas it will cost less—that there will be less loss in the main.

16550. (*Sir William Lewis.*) And less condensation?—Yes.

16551. (*Mr. Briggs.*) Putting it altogether, in order to guide us as members of this Commission, do you think that we can expect a sensible reduction in the quantity of coal used for power in this country?—The only way to deal with this question is the drastic way of "scrapping" the engines.

16552. Of course, the engines are wearing out, but is there enough inducement to make people scrap them at

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the present or probable price of coal?—Certainly there is, if they could be led to see it. I know lots of cases in which I would undertake to supply new engines if the people would give me the coal saved in five years.

16553. (*Mr. Maclay.*) Do you find mill owners and others in this country more conservative than people abroad in regard to the adoption of new ideas? I think it has been suggested here once or twice that that is so?—I may say what I was mentioning about the compound traction engines going abroad solely. There are very few of them sold in this country, but all the orders that we get for abroad—Colonial orders—are compound engines. The home threshing man says, "Oh, I do not want complicated machinery; I want something simple." He does not care about the economy; so that evidently there is more readiness on the part of the people abroad to adopt new ideas, where coals are dear—it gives them an inducement.

16554. (*Mr. Briggs.*) Yes, that is the point. They have to pay two or three times the price for coal?—Yes. Perhaps it would be a good thing for this country if the coal went up to double the price—it would make them more careful then.

16555. (*Chairman.*) You will find a diversity of opinion upon that subject?—No doubt.

16556. (*Mr. Brace.*) I am inclined to agree with the witness.—It would be a good thing for the saving of coal. I should put it in that way—that it would do more to save coal than anything else.

16557. (*Chairman.*) It would reduce the consumption of it?—It might be a bad thing for the country, but it would certainly reduce the consumption of engine coal if the price were high. We find people come and give us orders for economical engines when coals are dear, which they are not inclined to do when coals are cheap.

16558. (*Mr. Maclay.*) Coals are not any more expensive in Germany, yet we hear that in Germany new ideas are adopted more quickly than by manufacturers in this country. Is not that so?—Well, I could not say. I know that the Germans are very keen engineers in regard to making economical engines, and they make some splendid engines for mill purposes.

16559. (*Mr. Sopwith.*) You have almost answered one question which I was going to ask, that is, as to your views with regard to power gas. You have also mentioned your views as to the future of gas engines, but I rather understood you to say that in connection with gas producers for working electrical stations, there are only two stations. Is that so?—There were only two mentioned in this Table. There are more now. I took the figures on the 1st January in this year which really applied from 1901 to 1902. Quite a number of stations have been put down and are being put down now: there are installations both private and public. You may say that it is really within that time that the large gas engines have come forward.

16560. Quite so. The Midland Railway Co. have one?—Yes, they have several, but they do not show up so well as the steam engine stations.

16561. In those instances you have given us evidence upon, they do not show so well as the others?—No. I may say that the stations where economical steam engines are put in do not show up as well as they ought to do. One case I was very much disappointed in was where we made the engines and the figures came out well, but not nearly so low as they ought to have done, in my opinion. So I asked if we might make a complete test, and the electric lighting committee said yes. Then we went down and tested to see where the loss was, and we found that the auxiliary machinery in the station—machinery used for pumping the condensing water from the river into a large tank to run through the condensers (a thing we had objected to) and other auxiliary machinery, was using over 40 per cent. of the total steam used in the station. I brought this before the Committee and they were perfectly satisfied with what our engines were doing. I said, "No, I am not satisfied, because the consumption is too high, but there is the reason of it." They immediately got in tenders for other auxiliary machinery of a much more economical type, and spent some thousands of pounds in re-installing this machinery. It is much more economical, and it shows a better economy to-day. But auxiliary machinery as a rule runs away with a very large percentage of the total steam. I consider that the tramp steamer is the most economical power producer we have. Of course, the coal is a very large item with them, and I know that there are tramp steamers running to-day with as little as 1¼th lbs. of coal per indicated horse power as against 2 lbs., the figure mentioned here, and they drive all their own machinery: they have practically no auxiliaries, they drive their own pumps for circulating the water which you see coming out from the side of the vessel—they drive that off the main engines—they drive the air pump off the main engines, and drive the feed pump for pumping water to the boilers off the main engines, because they quite understand that where you put in an auxiliary engine you are working with a little engine, which is uneconomical. The tramp steamer, for that reason, is the most economical type of engine that I know in the steam engine world. Of course when you come to the Navy you have so many auxiliaries that they really are a very serious item in regard to the economy of coal. If you come to the mail steamers, you have certain things to consider, and there is a case in which you have to have auxiliary machinery. But in the tramp steamer, where they do not need to consider anything except economy, they are able, by doing everything from the main engines without auxiliaries, to get very economical engines.

16562. I rather wish to go back to the question of the gas engine for a moment: as I gathered, at the present time there is a question of the gas engine and gas producer competing with steam plant, but a great deal depends upon the improvements in the gas engine: in other words you might look upon the gas engine of the present time as you did upon the air compressing machinery some 30 or 40 years ago. Is that your view?—I think that the gas engine as an engine is about as efficient as they will get it: but the great economy in the gas plants will be in systems similar to the Mond for generating cheap gas for gas engines. I consider there is a great chance of that.

16563. My point is rather this, that you have given us this instance at Northwich where the Mond gas is in use?—Yes.

16564. The Mond gas is 0·48 per unit of fuel?—Yes.

16565. Whereas at Leeds we have the fuel at 0·27?—Yes, Leeds has 3,000,000 output, and large engines, and the Mond gas station is just a small station.

16566. I think I am right in saying that we have had it in evidence that there appears to be a practical possibility, even under the existing circumstances, of getting power at ·13d. per unit?—You ought to get it at less than that, if you take the thermal efficiency.

16567. In speaking of what is practical and actual I think I am right in saying so?—Well, I do not see why they should not get it at ·13d., but I am giving you these figures from actual practice, to show that in steam engine stations and gas engine stations the cost is largely affected by management.

16568. (*Chairman.*) The evidence you have given with regard to the tests you made is rather interesting, but it seemed to me to point to this, that in order to appreciate the real facts in comparing like with like, you ought to break the total up more into its component parts: in other words you have shown apparently that in certain engines you supply, the result of which, as regards the costs, was not satisfactory, it was not the fault of the engine, but it was that there was a considerable waste, or a considerable use of power for other purposes than the particular purpose for which that engine was driven?—Yes: but they were all connected with the work that this engine was doing.

16569. I agree: but, as I understood your evidence, it led to this result, that the printed costs of that station where the 40 per cent. loss occurred—the total costs—they were not satisfactory?—They were not satisfactory to me.

16570. But if they had been divided into what you have called the auxiliary purposes and the main purpose then it would have shown where the 40 per cent., or whatever it was, that you said was the amount of steam being used for those purposes, which hitherto apparently had been treated as of very small consequence, had gone?—Yes. What I wanted to bring out was this, that had they allowed us to make these engines exactly as we would have done, and put all this pumping gear on to our engines (which were economical, generating the power with a good economy), there would not have been this great loss. We would very likely have done with 5 per cent. what they took 40 per cent. to do.

16571. Quite so, but the reason why they did not let

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Mr. Henry McLaren.

5 Aug. 1903.

you do that was that they were previously unaware of the amount of steam that was used?—That is so, but we advocated it very strongly, and there were engineers on the committee. The river, of course, is a tidal river, the Tyne, and there is a large rise and fall, and, as they said, when it is low tide the engines would have to lift this water, and there would be trouble with the pumps, and there would be this, that, and the other, and to save trouble they go and expend fuel.

16572. (*Sir William Lewis.*) You said in reply to a question put to you by the Chairman, that you would "scrap" all the condensing engines which you describe as wasteful?—They are not as wasteful as most engines, but when they get to that stage I would "scrap" them.

16573. Then what would you adopt instead of them; would you adopt gas engines entirely?—I would adopt steam engines, seeing that I am a steam engine maker, but I would adopt the very best class of steam engines.

16574. Would you adopt them in preference to gas engines?—From the consumer's point of view I should have to.

16575. No, I mean from an economical point of view—from a national point of view. If the gas engine is a more economical way of applying the power which there is in coal, why should you not adopt it?—Well, it depends upon what you are using the power for; for instance, if you are using it for work that you are stopping and starting very often, or if you are wanting to reverse, then you must have steam engines.

16576. Then you would apply steam as far as that goes?—Yes.

16577. But for everything else would you apply gas?—Again, if it is driving electric alternators, for instance, there is the difficulty of running in parallel one steam plant with another. If you are driving an alternator perhaps, 100 periods a second, or fifty periods a second, that is to say, passing fifty magnets a second, before you can couple another engine in to help that, you must get that other engine running not only at the same number of revolutions per minute, but at the same periodicity; it must be just in step, it must synchronise, and with a large gas engine where it gets a large impulse every few strokes and nothing the next, the wheels are inclined to jump and pull the engines out of phase one with another.

16578. So that the Commission, in estimating the probable requirements of the future, would have to presume, according to your evidence, that a certain proportion of the coal would still be applied for steam purposes?—Certainly.

16579. And, according to the circumstances, a certain proportion would be more economically applied in the form of gas?—That is exactly so.

16580. (*Professor Hull.*) I should like to ask you one question with regard to winding engines for collieries, would you recommend gas engines?—Oh no, I would recommend steam; you could generate electricity and then use it for the winding engines.

16581. (*Chairman.*) Is there much winding done by electrical power?—On the Continent there is a good deal being done. If at a colliery, say, you have a central station generating the power, the electricity for the machinery down the mines and above ground it is quite feasible to wind by electricity.

16582. (*Professor Hull.*) Which would be generated by gas?—Yes; that is the way you could use a gas engine for winding purposes.

16583. (*Sir William Lewis.*) Do you know of any winding engine in this country working by electricity?—No, not colliery engines; but I think you will find it being used on the large building which is being put up close by here for the new War Office, where the cranes are running by electricity: they are winding up the material.

16584. That is a comparatively small load?—Yes, but you can get any power.

16585. And it is run at a very different speed to what we run our winding engines?—Yes, it is very slow as compared with a winding engine. You would want very large motors, and there you might have trouble.

16586. Yes, very large motors, and in such cases we lift several small tubs at a time?—That is so, and where you wind at such a high speed, of course you use enormous power for the time being.

16587. Where the cages run up to a speed of even 25 miles per hour?—Yes, but I think the steam engine will hold its own there, and it will hold its own in the marine trade, because you could not very well install a gas plant on a steamship. You might use oil engines, but they are not practicable for large powers.

16588. (*Chairman.*) Have you ever considered whether we shall make greater use of water power?—I do not think so in this country, because of the capital expenditure in the application of water. For instance, the interest upon the capital expenditure comes to practically the price of the coal, or more.

16589. The capital outlay is much larger than in the case of electric installation?—Yes, if you go to Switzerland or Norway, where you can have a fall at your hand and can put down your plant there, the capital expenditure is not a great consideration, but there is no method in this country that I know of by which that can be done without very considerable cost.

16590. You mean in carrying it some distance?—Yes, and in making dams. There is such a large expenditure involved that I really cannot see that they will ever be able to compete with coal by water power in this country.

16591. (*Mr. Young.*) If we had no coal, do you think it would be practicable to utilise water?—I think I would grow potatoes and make alcohol, and run alcohol engines.

16592. (*Chairman.*) Do you exclude the possible use of radium?—I have not considered radium sufficiently; you must ask Professor Lodge or some of those gentlemen with regard to that.

16593. (*Professor Dixon.*) In giving these results for the steam engines that are being used, have you taken into account the use of the turbine, or are they all reciprocating engines?—I may just mention what I said with regard to turbines in the paper that I read to the Institution of Mechanical Engineers at their meeting last week. "Steam turbines.—There are only four stations given in the tables wholly using steam turbines: Newcastle District"—(There are two companies in Newcastle, the Newcastle and Newcastle District, and this is Newcastle District),—"Scarborough, Cambridge, and Melton Mowbray."

16594. What are these being used for?—These are the only four stations wholly using turbines for generating electricity.

16595. Is this for electric lighting purposes?—Yes; all of them are for electric lighting purposes. "Newcastle Station is the lowest, both in coal and works costs." The figures are given in the Table in this pamphlet, and you will be able to refer to any station you like.

16596. Will you put that in as part of your evidence?—Yes, it can be referred to for any particulars you require. "Newcastle Station is the lowest, both in coal and works costs; yet it is easily beaten by South Shields, a station with vastly less output, situated on the same river, and using triple expansion condensing engines, which comes out 35 per cent. less in fuel and 25 per cent. lower in works costs than the turbine station."

16597. (*Sir William Lewis.*) Is the fuel taken at the same figure in each case?—I took two stations on the same river as being cases in which it was most probable that coal would be the same; South Shields is only seven or eight miles down the river from Newcastle, and they are both on the riverside, and the fuel in those cases ought to be alike. You see I could not write to the engineers; they would not care to give me the particulars if I wrote to every station in the Kingdom. (*Mr. Briggs.*) The difference might be in the boilers.

16598. (*Sir William Lewis.*) Or you may have round coal used in one case, and small coal in another?—Yes, but the chances are that they are alike in coal, the boilers are, as a matter of fact, of different types, I know. But take the stations as a whole; I have taken the best turbine station and pitted it against one of the best steam engine stations, both in the same neighbourhood, of course. It would not be fair to take a London station as against South Shields, but I think Newcastle and South Shields may fairly be compared.

16599. (*Professor Dixon.*) This is a triple expansion engine, I think you say?—Yes. You will find, by looking at the Tables, that South Shields is one of the best and most economical for a small station.

16600. (*Chairman.*) Is that the station that is going to supply the North Eastern with electricity?—No, that

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is the Newcastle Company at Wallsend. They are using turbines, but they also have steam engines. You cannot get at their costs separately.

16601. But is not that the one upon which Parsons' turbine is used?—Yes: Newcastle District Station was started by Parsons', and the turbines there are all Parsons'. But this large turbine station that is to supply the North Eastern belongs to a different Company down at Wallsend, and they are now going in for turbines in preference to large steam engines.

16602. Are they not fitting up these large Metropolitan works in London with turbines?—Yes: that is the Westinghouse Company with a Curtis turbine, an American turbine: it is copied largely from Parsons, but with improvements.

16603. (*Professor Dixon.*) Where does the large economy come in: is it because the repairs are less in the case of the turbine?—No, it was the steam engine that produced the greater economy in that case.

16604. Yes, you told us so. Then why are the turbines being put up in these stations?—Well, when you come to the large size, it is such a simple thing as compared with a large steam engine, and I daresay cheapness has something to do with it: and the wear and tear is bound to be less, unless they go to pieces altogether, which they sometimes do.

16605. Then may I take it that if at South Shields they had a much larger output to deal with, it might be more economical to use the turbine?—No, because the South Shields output is much less than the Newcastle, and still it beats the turbine. *Mr. Henry McLaren.* 5 Aug. 1903.

16606. I say if it was a much larger output possibly the turbine would be more economical?—Well, of course the larger the turbines the more economical they come out. A turbine is not an economical thing, as a rule, but the larger they get them the better they come out. (*Mr. Sopwith.*) It is very necessary that we should know the price of coal in a case of this sort, because you see in South Shields they have a colliery which is quite inside South Shields, and it is possible that they can actually dump the coal out of the colliery into the works, and in other cases it may be brought in by rail or by steamer, and it would be tipped, and so on. It is quite possible that the difference may all be due to the coal.

16607. (*Sir William Lewis.*) You cannot institute a comparison that is of any value unless you have the figures of the coal?—No, and unless you get the actual heat of the coal.

16608. (*Professor Dixon.*) In making the comparison, did you consider the price of the coal?—No; all these comparisons are made on the returns for the Board of Trade, and they are given in pence. But it is not fair even to take the price of the coal only; you must also take into account the heat of the coal if you want to make fair comparisons. (*Professor Dixon.*) Yes, quite so. I meant the thermal unit.

TWENTY-NINTH DAY.

Thursday, 6th August 1903.

PRESENT:

The CHAIRMAN.

Sir GEORGE ARMYTAGE.
Mr. BELL.
Mr. BRACE.
Mr. BRIGGS.
Professor DIXON.
Professor HULL.
Mr. SOPWITH.
Mr. TEALL.
Mr. YOUNG.

The SECRETARY.
The ASSISTANT SECRETARY.

Mr. W. NELSON HADEN, M. Inst. H. & V.E., M. Am. Inst., H. & V. E., called; and Examined.

16609. (*Chairman.*) We have your statement, which seems to be clear and consecutive. If you will read it to us, any questions arising upon it can be put afterwards. Perhaps that will be a convenient way of getting it on the notes in a consecutive form. Your evidence relates mainly to heating plants, does it not?—Yes. *Mr. W. Nelson Haden.* 6 Aug. 1903.

THE ECONOMY OF FUEL EFFECTED BY CENTRAL HEATING INSTALLATIONS.

(1). The almost universal method of heating buildings in this country has been by means of open fires, except in the case of large institutions, public buildings, and private mansions, and in these cases open fires are usually provided in addition to a central heating plant, either for appearance, ventilation, or auxiliary heating.

One of the first considerations, therefore, in connection with economy of fuel is to find the form of grate for open fires which gives the best result in heat units imparted to the room per pound of coal consumed. The many requirements of style will demand different forms for different circumstances.

As no doubt you have, or will have, evidence before you with regard to this question of grates from those well qualified to give it, I do not intend to comment further upon the matter, except as to one form in the use of which I have had some experience, that is, the ventilating grate.

(2). Ventilating Grates:—These grates are of different form and construction, some being formed in metal and some in firebrick, the object in either case being to make use of the heat given off to the back, and in some cases to part of the chimney, by the introduction of fresh air to the back of the grate or chimney, or both, which air being thus warmed is admitted to the room.

The heat thus gained is a clear saving. The radiant heat given off to the room by a firebrick back would not be sensibly reduced by the reduction of a comparatively cool air space behind it, while with a metal back, though the amount of heat radiated to the room would be somewhat diminished, the units of heat taken up by the air in its passage over the hot back would more than compensate for this loss.

These grates are also arranged with descending flues, so that they can be placed centrally in large rooms, such as hospital wards, in which position, no heat being lost by direct conduction through outside walls, the greatest possible quantity is imparted to the room.

If the ward, however, is a large one, supplementary heat would be required against the outer walls to counteract the cooling effect of the wall and glass surface.

The additional advantage of the introduction of fresh air is a matter that concerns ventilation, and need not be dealt with here.

(3). I append the result of a comparative test of the heating effect on a room fitted with a ventilating grate of the form named above, constructed of iron, which will serve to demonstrate the economy effected by the use of the ventilating back as compared with the same grate

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Mr. W. Nelson Haden.

6 Aug. 1903.

under the same conditions, but with the special back not used.

The size of the room was 24ft. by 18ft. by 12ft. high, with a bay in addition 12ft. by 5ft. by 12ft. high, having a cubic content of 5,900ft. The room had two and a-half outside walls, with a glass area of 120 square feet: the building was one floor only in height, with no basement.

16610. (*Sir George Armytage.*) What do you mean by two and a-half outside walls; do you mean two and a-half feet brick?—No, the equivalent of outside wall was equal to two and a-half, that is, there was a low building on one of the sides which did not come more than about half way up the wall, and did not extend quite to the end of the wall on that side: the effect was that about half that side of the room was covered by another building.

16611. You mean two sides of the room and a half of one side of the room were outside walls?—That is it.

The tests were made on two succeeding days, one whole day being occupied in observations under each set of conditions. The mean outside temperature was two degrees higher on the day when the ventilating back was not used, but otherwise the atmospheric conditions on the two days were identical. The same quantity of fuel was used on each day, and the fire was fed with the same quantity and at the same intervals in each case. The conditions were thus as similar as it was possible to make them.

The mean temperature of air in the room when the ventilating back was used was 18·3 degrees higher than that of the outer air, while when the ventilating back was closed the difference was only 9 degrees. Of course, the temperature of the walls did not vary to this extent, the difference at the inner surface being only about 3 degrees.

The economy in this case due to the ventilating back was perhaps 35 per cent., that is to say, assuming that the grate without the ventilating back was sufficient for the room, the occupants would have been equally comfortable with a 35 per cent. reduction of fuel consumption with the ventilating back in operation.

This result is fairly representative of the saving to be effected by the use of the ventilating back as a means of preventing a part of the large waste of heat which the use of an open fireplace involves. The 15 per cent. allowance which I have made there is, I consider, liberal for the amount of heat which was perhaps retained in the walls from the one day's test to the other.

16612. (*Chairman.*) Have you the figures of temperature? You give us the difference, but you do not give us the temperatures?—The test being taken in rather warm weather I thought it would be perhaps misleading to give the figures of the actual, so that I only gave the comparative, temperatures.

16613. You assume that there would have been a reduction of fuel, and that the conditions would have been equal with the less consumption of fuel with the ventilating grate than without it; but have you made any test to show that in practice a less quantity of fuel does produce the same temperature?—I have not made a test on those lines, that is to say, the lines of equal temperature with the fuel required for that temperature. Some of these tests I might, if I had had a little more time, have been able to add to by experimenting in the way you have suggested.

16614. You see that it would get rid, at all events, of the possibility of the disturbing factor between practice and theory, if it had been shown that with a consumption of coal 35 per cent. less, the same temperature and conditions were maintained—it would have been, at any rate to the lay mind, clear that in practice the theory worked out?—In taking it in the way that I have done here, I have, of course, taken it on the amount of thermal units which are imparted to the air in the room by a certain quantity of fuel. It is really based upon that; so that if the same quantity of fuel with the ventilating back in use gives an additional amount of thermal units, then there should be a corresponding saving by the use of air admitted from the back, which would be an equivalent to that.

16615. Yes, and therefore it would not have been difficult to have made the experiment with a less quantity of fuel, so as to complete the test?—Yes; but perhaps it would be more difficult to maintain exactly the temperature—to work to the temperature—than it is to work with the amount of fuel.

(*Mr. Briggs.*) But it hardly follows that it would be exactly the same, because you can imagine that a person might be overfiring the grate in one instance. I mean you could pass more coal through without necessarily making more heat if you passed it through wastefully. If the other experiment could be made, it would be more conclusive.

16616. (*Chairman.*) It brings it home to the lay mind clearly, I suggest?—I thought by adding a certain amount of coal at certain intervals we should get a reliable quantity which we could exactly determine, but if you are trying to work to a certain temperature, you may exceed that temperature, or fall below it, owing to the fire not giving exactly the amount of heat which you would anticipate from the amount of coal put on, as to which you would have to depend, to a certain extent, on your own judgment.

16617. Yes, I agree, but you see my point: supposing you adopted the plan of firing at the same intervals with the same quantity of coal, then you test the results, and you make a calculation which you say is a fair one, which shows that the conditions produced without the ventilating back would have been produced with the ventilating back at an expenditure of 35 per cent. less fuel?—Yes, I see your point.

16618. My suggestion is that if the use of the coal put upon the fire, if you like at the same intervals, had been 35 per cent. less in the one case than in the other, that would have shown whether the theory worked out in practice?—Yes, that would have been an additional test which would have been an advantage, but I have not those figures prepared in that way.

Private Houses.—In this country the temperature does not necessitate the heating of all the rooms of a house, including bedrooms, and for this cause heating apparatus are not in such general use for private houses as they are in America and on the Continent, where the winter temperature is much lower. It is, however, becoming much more general even in this country to heat all the rooms in a house, and those who have had experience of a house so heated have frequently assured me that they would not on any account live in a house without such an installation, Of course, in connection with a system of this kind proper provision must be made for ventilation, the absence of which accounts for much of the prejudice against such systems in this country. There is no question as to the superior economy in fuel of a well designed heating apparatus over open fires where similar temperatures are maintained. I was recently called upon to make a test of an installation where every room in a private house was heated, and the result of this test will give an idea of the amount of saving which may be effected by the installation of a central apparatus in the place of open fires. There were in all 35 apartments, besides corridors and cellars, heated by a low pressure hot water apparatus with radiators. The total content of rooms and corridors heated was 96,700 cubic feet, not including cellars, which were somewhat warmed by the mains passing through them. Many of the rooms were small. The consumption of fuel for 24 hours was 686lbs.; the internal temperature maintained throughout the day, being an average of 60°, with an external temperature of 42°. I do not give this as the best result obtainable (or even as a good result), as there were many points in the arrangement of the apparatus where improvements could have been made. I quote it, however, because it was a case where every room was heated. To heat this house by open fires would have involved the use of 40 fires.

16619. You say the consumption of fuel for 24 hours was 686lbs., the internal temperature maintained throughout the day being an average of 60°, with an external temperature of 42°. Does that mean the average through the day of all the rooms?—It is the average of all the rooms during the time.

16620. I am afraid I am not making my point very clear: is the average the lumping together of varying degrees of temperature, 60° being the average?—Yes, that is it; that is the average of all the rooms.

16621. That is to say, one room might be 70°, and another might be 50°, and that would give you an average of those two of 60°?—Yes.

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16622. It is not an uniform temperature of 60° throughout the whole house?—No, it was an average temperature.

16623. (*Mr. Bell*). How much would it vary in the different rooms, do you think? Have you any idea of the temperature in the different rooms?—I daresay there might be a variation between extreme rooms; that was a test taken in an arbitration case, and there was more variation than there would be with a good apparatus. There might have been a variation there, I think, of 10° between the coldest and the hottest rooms.

16624. (*Chairman.*) But I take it, the pipes of the heating apparatus went through the corridors: the corridors were heated as well?—The corridors were heated, and they are included in the cubical contents; they were heated by radiators.

Taking the consumption of coal by an ordinary average grate per day at 40lbs. for a room of 2,500 cubic feet content, this would have meant a consumption of 1,600lbs. per day, showing a saving by central heating, even with a poor apparatus, of 57½ per cent., in addition to which the heat in the apparatus was maintained during the night, for which an average consumption of 40lbs. per grate in an open fire would not suffice. I may say that that figure was taken as the average of an ordinary sitting-room, and a note made of the quantity burnt during cold weather.

16625. (*Mr. Bell.*) There would be a very important difference between burning coal in open fires for 24 hours, and burning for 10, 12, or 16 hours.

The initial cost often prevents a central heating system being installed, but if put in when the house is being built, the cost is considerably less than if added to an existing house. This is especially the case with a ventilating warm-air apparatus. Take a new house containing hall and three sitting-rooms: such an apparatus as would heat those apartments, and also air any bedrooms opening off the hall, could be put in for some 5 per cent. on the cost of builders' work, and for a house of, say, 40,000 cubic feet content, would burn some two tons of coke during an average winter.

16626. (*Mr. Young.*) Do you take 5 per cent. in addition to the fire-places; does that make an allowance for the fire-places not being built?—It would depend, of course, very much upon the construction of the house; I have taken that as an average cost against what would be the cost of the builders' contract for a house, not including furnishing.

Such apparatus can be provided with a humidifier, doing away very largely with the dryness which is often complained of in connection with apparatus of this kind. The quantity of coal which would have been used to produce a similar but inferior result by open fires would have been not less than 9½ or 10 tons for the winter. I may say that that apparatus is a simple apparatus which would get over the difficulty that is often raised as to the cost for installation in these matters.

16627. (*Chairman.*) You are speaking, as I understand, of a house warmed by a central heating apparatus, as you call it, with no open fires?—It would do away with the necessity of open fires: it would heat the house without them. Of course that is not including the question of cooking or kitchen fires.

Heating of small houses.—I may say that this paragraph with regard to the heating of small houses is partly in connection with a central or estate heating, which I will mention a little later on, but as I am dealing now with private houses, I have inserted it here. The saving of fuel which might be effected in an ordinary small and medium-sized house by the adoption of central heating plants serving a number of houses in close proximity to one another would be very considerable. Fuel is used for heating living rooms and bedrooms, and for cooking. To this, in the better class house, may be added the fuel for heating greenhouses and for general garden or stable purposes.

Apart, however, from the heat required for additional purposes the amount of fuel consumed in an ordinary small middle-class house, say, from 12,000 to 25,000 cubic feet total content, is from 5 to 8 tons per annum. The greater part of the fuel used for domestic purposes in this country is consumed in houses of this class. I have no doubt that if central heating alone were generally adopted for such houses where possible, a saving of 60 per cent. of the fuel now used in such houses could easily be effected, and in addition the heating made much more thorough than is the case with the present method of open fires.

Mr. W. Nelson Haden.

6 Aug. 1903.

How far the present prejudice in favour of open fires would prevent the general adoption of this method it is difficult to estimate. There is no doubt that a strong prejudice does exist in the minds of the general public against all forms of heating apparatus other than the open fire. This is probably due, in the main, to the lack of adequate ventilation, which is observable in many old-fashioned appliances, but there is no reason why adequate ventilation should not be provided along with a heating apparatus, or why, if an open fire is desired for the sake of appearance, it should not be of much smaller dimensions than those now commonly seen. By this means the advantages of both methods would be to some extent obtained, and great economies in coal consumption secured.

Cooking.—The amount of fuel used in an ordinary closed range 4ft. wide for a middle-class family of four persons varies from 25lbs. to 60lbs. per day in practice, the former figure representing economical management of the fire, and the latter being the consumption when the fire is kept at full power for 12 hours. More fuel is frequently used in such a range than would be necessary for cooking, in order to warm the kitchen premises. Probably half of the whole would be saved by the adoption of steam cooking appliances for the lower, and gas for the higher, temperatures.

The initial cost, however, of apparatus for utilising steam heat for culinary purposes would be considerably higher than (probably three or four times as much as) the cost of a range, though if steam heat were generally adopted there is no doubt the cost of such appliances would be greatly reduced.

Cooking by gas is becoming increasingly common, and there can be no doubt that, apart from the question of economy for the individual householder, the general use of gas for cooking purposes would reduce the total consumption of coal.

16628. (*Mr Briggs.*) Do you mean that gas cooking might be more expensive to the person who pays for the gas, but that there would be far less fuel used for producing that?—Not only would it be cheaper for cooking if the gas were economically used, but the amount of coal that would be consumed in producing that gas at a gasworks would be very much less than the amount of coal which would have to be burnt in a range so as to produce the same effect as far as cooking is concerned.

16629. I readily believe the latter part of it; but the former part I rather doubt. I mean cooks, as a rule, are very extravagant with the gas just as they are with coal?—Of course, everything depends in economy of gas-cooking upon the cooks. If they would only remember that approximately it takes three times as much gas to boil a kettle as it does to keep it boiling, and adjust the burners accordingly, it would make an immense difference. When those matters are looked after, as well as the point I named with regard to kitchen ranges, economy is obtained. Kitchen ranges burn almost anything if they are allowed to roar away, but by proper arrangement of the dampers you can make the difference I have alluded to here—between 25lbs. and 40lbs., and the same thing would apply to gas cooking. I have mentioned the question of cooking here, but it comes in more with regard to the estate question, which I will come to later on.

16630. (*Mr Young.*) Could you heat the water at the same time that you make the gas with the same fuel?—Do you mean in the range?

16631. Yes, and using the waste heat; could they not do that as well?—The heating of water for domestic purposes by gas becomes expensive. I have known appliances put in in some cases, but I have known them to be taken out when the first quarter's gas bill came in.

(*Mr. Young.*) That is not my question. I do not know that it is very pertinent, but it was whether, when you were boiling the water for circulating in the houses, you could not at the same time make the gas from the same fuel.

16632. (*Chairman.*) It contemplates a separate gas plant for each house?—Yes, that amounts to a gas-making plant, and it means practically putting your boiler over

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Mr. W. Nelson Haden.

6 Aug. 1903.

your retort. I am afraid that would be a rather expensive plant.

Schools.—It is somewhat difficult to get data for comparison with regard to schools, as in those schools where a central heating apparatus is installed provision is usually made for a larger interchange of fresh air, and consequently a considerable proportion of the fuel is consumed in warming the additional amount of air provided. The following figures are instructive as showing the relative fuel consumption for the 12 months from July 1st, 1902, to June 30th, 1903, in three different public schools (Board schools) in the same locality, heated by different methods.

The three schools, indicated by the letters A. B. C., were of different sizes, but the buildings were of the same character, with approximately the same relative proportions of content, wall surface, and glass surface, so that they are strictly comparable, in spite of the difference in size. The fuel used in school A, however, includes an amount for heating a swimming-bath. The fuel for this purpose was not kept separately, but the amount of it was determined by separate experiment and calculation. Also, the quantities actually used in cases B and C included a certain proportion for the masters' houses which was taken from the general stock. This also was calculated from separate experiments, and these results deducted in the figures now given. The proportion of the whole is not so considerable as to vitiate the conclusions drawn, and the figure may be relied on as representative of the various methods of heating. It will be seen that in the case of C the ventilation was mechanical, and the quantity of air driven into the building was sufficient to change the air from eight to ten times per hour.

16633. (*Professor Dixon.*) How was that ventilation worked in C?—By means of a fan.

16634. What was driving that fan?—A gas engine.

16635. Was that counted in the fuel, or not?—No.

16636. It was quite separate?—The consumption of gas for mechanical driving is not counted in that fuel.

In B the ventilation is much less thorough, flues and open windows being used, this irregular method, no doubt, causing a large waste of heat.

In the result, it will be seen that the best method is also the cheapest per head for fuel, and by far the most healthy, though also the most expensive to instal.

16637. (*Chairman.*) Would you say what is the evidence in the table, or what is the indication in the table that in B the ventilation is much less thorough?—The ventilation there was simply by means of flues, without any fan.

16638. That is not quite my point. You say: "In B the ventilation is much less thorough, flues and open windows being used, this irregular method, no doubt, causing a large waste of heat." Then you go on to say: "In the result, it will be seen that the best method is also the cheapest per head for fuel." That is C?—Yes, the third.

16639. And you say the best method is shown by the fact that the air is changed eight or ten times per hour?—Yes; of course, there is that additional air to be heated, in addition to what would be heated if there was not so much air passing through.

16640. That is a question of consumption of fuel, but I thought it meant the best method as regards ventilation?—Yes, it is decidedly that; but I have omitted as far as possible discussing any question of ventilation here, and confined myself as far as possible to the coal consumption.

16641. (*Professor Dixon.*) Did you make any analyses of the air in the rooms to justify that statement that the ventilation was much less thorough in B? The cost you see comes out at pretty nearly the same—146 and 148lbs.—but was the ventilation very much better, and if so, how did you arrive at that?—The ventilation in the latter case would be measured; the air would be measured.

16642. Yes, in C?—In C.

16643. The amount you drove into the premises?—Yes.

16644. But in B?—In B I have no data as to what air was passing through. It is almost impossible to get that when they have windows open.

16645. Is it merely your judgment that it was better, or did those who lived in the room say it felt bad in B, or something of that sort?—Well, it is what we have found by experience to be the case. They would not open the windows if they found the flues sufficient; if they found the air in the rooms was being changed sufficiently by the flues which were provided in that school they would not have wanted to open the windows.

16646. (*Chairman.*) The simple temperature of 60° as against 50° is not in itself a sufficient proof of better ventilation, is it?—The point of the 50° there, was that by the open fires they were unable, without the assistance of gas, to raise the temperature in those schools. This is an older school.

(*Chairman.*) Yes; but, of course, you get a much larger number of children in the school.

(*Professor Dixon.*) I do not think so; there are less for the room.

(*Mr. Briggs.*) A is the case of open fire.

(*Chairman.*) But you have in one case accommodation for 294 children, and in the other case for 995 children.

(*Professor Dixon.*) Yes, but in the first case it is 44,000 cubic feet.

(*Chairman.*) I agree, but I am only suggesting that. I do not know what excess of heat each animal possesses.

(*Professor Dixon.*) But I understand the witness to say it is the proportion of children to the cubic space.

(*Chairman.*) Yes, and to the extent that you limit or otherwise the exchange of air or the admission of air or the loss of air, so you would raise the temperature, would you not, by the number of children? If you get 1,000 children in a room, however large, and did not admit much air, you would raise the temperature, I think.

16647. (*Professor Dixon.*) Is that what you are putting? May I ask you that question? In case C you know the air was changed eight to ten times per hour?—Yes.

16648. You have the same temperature in B, but you judge that the air was not changed anything like so often?—No.

16649. Therefore, there would be better heating in C from the fuel point of view?—Yes, in point of fuel consumption.

16650. Better than in B—that is your point?—Yes, that is my point there. I should judge, although I have not tested, that probably the interchange of air in the case of B was not more than three times per hour.

16651. But you made no actual chemical tests?—I have no test of that.

It should also be noted that the mean temperature maintained in A was about 10° lower than that in B and C, and to raise the temperature in this school to the same level would have required at least one and a half times the consumption here shown, if, indeed, it would have been possible at all.

FUEL Consumption in three Board Schools in the same locality heated by different methods.

School.	Content.	Accommodation. Children.	Method of heating and degrees maintained.	System of Ventilation.	Total weight of fuel used for school heating only.	Total weight of fuel per head for heating only.	Over all cost of fuel per head. Shillings.
A	44,000	294	Open fires, 50°. F.	Windows.	40·5 tons.	309 lbs.	1·5
B	180,000	995	Combined warm air and water, 60° F.	Flues and windows.	66 tons.	148 lbs.	0·99
C	250,000	1,100	Hot water, direct and indirect radiation, 60° F.	Mechanical plenum, 8 to 10 changes per hour.	72 tons.	146 lbs.	0·98

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In further illustration of the same point, I will quote the case of another school, having accommodation for 1,300 children and a total content of 300,000 cubic feet, which was originally heated by open fires, and which was so cold in severe weather that the fires had to be supplemented by lighting all the gas jets in the building. Under these circumstances, the average weekly consumption of coal alone was 2 tons throughout the winter.

After the installation of a hot-water apparatus it was found that the rooms were kept comfortable in the coldest weather without resorting to such insanitary devices as lighting the gas jets, and at the same time the total consumption fell to an average of 1¼ tons per week. A rough agreement will be observed between the economy effected in the two cases.

Offices.—In blocks of offices which are let off to different tenants a great economy in heating can be effected by a central system supplying heat to all offices. An important item in connection with such an installation is the reduction of the number of fires producing smoke, as with a central apparatus the smoke can be better controlled. New York, where nearly all offices are so heated, and where the use of anthracite coal for such purposes is compulsory, is an almost smokeless city. Where blocks of offices are sufficiently large to justify a separate installation for electric lighting, still further economy can be effected by utilising the exhaust steam from the engines used for generating current for lighting, electric lifts, or pumping, if hydraulic lifts are used. The steam is used for heating the offices in winter, and also for the supply of hot water in both winter and summer for co king, and for other purposes.

In this way one can utilise the heat from the exhaust steam which would be lost in the case of non-condensing engines by being discharged to the atmosphere, or, with a condensing engine, dissipated in the condensers. In office blocks cost and space would usually preclude the use of a condensing plant.

Thus by combining a plant for electric lighting, lift work, etc., with installations for heating and for supply of hot water, these latter can be obtained for a very small extra cost in fuel, or, to look at the matter from another aspect, electrical power can be provided in winter for a small additional expenditure in fuel beyond what would be required for heating and hot water supply. That is to say, a large proportion of the fuel required for heating and hot water supply on the one hand or for electric power on the other would be saved. The proportion would depend upon the varying requirements of each individual installation. The buildings could be heated either by exhaust steam direct or by low-pressure hot water heated by the exhaust steam.

Public Buildings and Large Institutions.—In large public buildings or institutions, such as asylums, hospitals, etc., when the whole is under one authority, and is worked by that authority, there is no difficulty in carrying out such an arrangement as is outlined above. A judicious expenditure of capital upon plant will enable the whole of the various services for which fuel is required, viz., lighting, heating, hot water supply, cooking, laundry, and pumping to be so arranged that the coal consumed can be used to the very best advantage. In such a combined scheme the use of economisers for taking up the heat from the gases after leaving the steam boilers, and the conservation of condensed water, greatly helps towards this result.

In one plant with which I am well acquainted, the temperature of gases after leaving the boilers was 500°, and after passing through the economiser it was only 370°, this still being sufficient to give an efficient draught for the boilers. In another plant, of which a very thorough test was made by my firm, the adoption of an economiser effected a clerr saving in fuel consumed of 19·5 per cent., the conditions before and after the addition of the economiser remaining identical.

By the return of the condensed water, which in another plant formed 87 per cent. of the whole water required to feed the boilers, the heat in the water, which returned at a temperature of 160° F., was conserved, and this being distilled water, it would further obviate all incrustation on the boiler plates, which with hard waters causes a good deal of loss of heat. The extra fuel required to compensate for incrustation in boilers is approximately as follows:—

Where the incrustation is ⅛in. thick, 5 per cent.; ¼in. thick, 10 per cent.; ⅜in. thick, 15 per cent.; and ½in. thick, 20 per cent.

Mr. W. Nelson Haden.

6 Aug. 1903.

The economy of such a combined plant may be seen from the following figures:—The amount of coal used for one of the plants above referred to, which provided for the entire requirements of the inmates of the institution—numbering, with attendants, an average of about 2,300—was in 1902 3,100 tons for lighting, heating, hot water supply, cooking, laundry, and pumping. Had the services been worked separately, the fuel consumption would have amounted to 3,900 tons. This shows a saving by combined central plant of 800 tons per annum, or about 20·5 per cent., as against the combined consumption of separate central plants for each service. The figures amounting to 3,900 tons I have computed from other tests which I have taken of plants where these services are worked separately.

Such instances might be multiplied, but I think this will be sufficient to show the economy in the consumption of coal that could be effected if such plants were generally adopted.

Estate or Municipal Heating.—The experience I have had in connection with such central plants as are named above has led me to consider the loss of heat in connection with electric light and power stations. These are now springing up all over the country, and in many cases, especially where the stations are mainly for lighting, there is a large amount of exhaust steam being discharged into the atmosphere. The whole of this, of course, is wasted. In other plants, where condensing apparatus is provided, there is a large amount of heat lost in the water used for condensing either in rivers, cooling ponds, or cooling towers.

If separate lighting plants were put down for compact estates the houses on the estate could be heated and supplied with hot water from the exhaust steam produced by the electric light engines. The heating could be done by means of the exhaust steam direct, or by hot water heated by the exhaust steam and circulated by means of pumps through mains connecting with the houses on the estate.

With municipal stations the question becomes more difficult, as the municipality would hesitate to put down plant for heating a portion of the city nearest the power station, which until such time as a number of houses were connected would be unremunerative. In an ideal "garden city" such a scheme should certainly be considered. As I have shown, there is a great waste of heat from large power stations, which could easily be utilised for heating purposes, and as electric power is so fast displacing horse traction, such stations which consume a large amount of fuel are rapidly increasing.

Large economies in the use of fuel are therefore to be secured by making arrangements for utilising such waste heat in the manner I have indicated.

When in America last year I saw in one of the suburban towns near Chicago an installation carried out on these lines. About 200 houses were heated and supplied with hot water from the electric light station, which was also supplying them with light, and this was done almost entirely with the exhaust steam. Some of the houses at that time were situated 7,400 feet, or nearly 1½ miles from the station. In this case the heat was conveyed by hot water. There are a large number of similar installations in the United States, but few, if any, have been erected in this country. The difficulties placed in the way of a company seeking powers to carry mains through the streets in America are much less than is the case in this country.

In 1898, when it was proposed to erect a number of houses with shops and a promenade under the cliff between Bournemouth and Boscombe, I designed, in connection with our firm, a scheme for the supply of light and heat from a central station. It was a condition that there should be no chimneys from the houses, and by the use of gas for cooking these were by this scheme rendered unnecessary. A considerable portion of the heating of these terraces (over a mile long) would have been done by the exhaust steam. The scheme was not carried out on account of the opposition of local landowners to the idea of putting up houses in the place of the natural cliff, but I refer to it as an example of what might be done in this direction towards economy in the use of fuel by means of central installations. It was proposed (gentlemen who know Bournemouth will follow me) to put between Bournemouth Pier and Boscombe Pier a promenade road along the front, with shops opening from it, and a higher road above that with boarding

Digitized by Google

Mr. W. Nelson Haden.

6 Aug. 1903.

houses built in against the back of the cliff, but not coming above the line of the cliff. No chimneys would have been carried up, but flues would have been provided for ventilation only, and the roofs would have been laid out as gardens or promenades, with the central heating station placed somewhere between the two piers.

16652. (*Mr. Bell.*) So that there would have been a warm weather walk on the top of those houses?—Of course, the tops of the boarding houses would have been for those in the houses themselves, but there was to be a promenade in front of them, the road running between the two piers from end to end.

I have in the foregoing drawn your attention to the questions of the economy of the consumption of coal in connection with the heating of private houses, office buildings, public buildings, institutions, and estates, or portions of towns and cities, and I trust that what I have been able to lay before you will be of some service.

16653. (*Chairman.*) Would you say that the use of what you call central plants or the heating of buildings by means of hot water or in other forms is growing in this country?—I think very decidedly.

16654. Is it being adopted, for example, in blocks of buildings which are let out as flats in London?—In some cases, but that has not been done very much.

16655. As regards flats generally, not even the corridors are heated, are they?—I do not think they are. I have not had much experience personally in the question of flats.

16656. You speak of a ventilating grate. Does the observation apply to some particular grate which you have in mind, or are you speaking of a ventilating grate in the abstract?—Taking ventilating grates generally, but the grate on which I made the test referred to was one made by our firm.

Supplement Plate 26.

16657. But it is applicable, as I understand, to an open fire, or may be made so?—To an open fire with a hollow back, such as the Shorland grate and Captain Douglas Galton's grates—he was one of the first who brought out those grates.

16658. Have you any sketch of the grates with you?—I have no sketch with me. I rather refrained from bringing any photographs or any particulars of things which I had myself, because it would rather appear as if I was bringing them perhaps for my own firm, which I endeavoured to keep clear of as far as possible.

16659. (*Chairman.*) That is a very good reason, but, of course, the point is to get it into our minds what the thing is. I dare say you would be willing to send one if we wanted it?—Yes, I shall be very pleased to do so.

Supplement Plates 25 and 26.

16660. (*Mr. Bell.*) Was that a municipal undertaking in the suburban town near Chicago where they heated the district, or was it a private concern?—A private company.

16661. Do you mean a public company?—Well, it was not taken up by a municipality; it was the company that had the lighting of that suburban town.

16662. And they had power to charge for the use of the pipes?—They laid the pipes through the streets, and they charged a rental on the amount of heating surface which was installed in each house.

16663. (*Chairman.*) Did the houses—the property—belong to them?—No, the houses were owned by private people.

16664. It was just an agreement to supply them with heat?—In exactly the same way as you would supply gas, water, or light.

16665. You refer to the Garden City Settlements; has there been any application of this principle to any of them as far as you know?—No, I believe not. I was thinking rather of the Garden City idea which has been spoken of lately in England, and as to which, according to the plans, the suggestion is for the whole place to be laid out with a view to the future. I thought that such a scheme might be worked in, because the whole concern would on the proposed lines belong to the municipality itself; the municipality would be the owner of all the ground, and, of course, could then deal with the thing very differently to the way in which a municipality with various owners could deal with it.

16666. (*Mr. Bell.*) It is an ideal city?—Yes.

16667. (*Mr. Sopwith.*) It has taken rather a practical form just now, has it not? There is one Garden City which is likely to be carried out?—That is the point I was referring to.

16668. (*Chairman.*) But that is not municipal, is it?—No, but it was proposed in that case that the municipality of the Garden City should own the whole of the property, and let the houses off, so that they would retain the ownership of the whole concern.

16669. (*Mr. Young.*) In the case of the American town, near Chicago, you visited it, I believe, and saw those houses, did you not?—I was not in the houses, but I was at the central station, and I obtained my information from the central station as to what was being supplied. I saw the water as it was going out and the temperature of the water coming back.

16670. You did not obtain any information from the residents as to how they approved of that over the whole system, did you?—No; of course in America all houses are heated by other means than fires; in fact, there are very few offices or such like buildings that are heated by fires at all.

16671. Would not ordinary houses in the towns have fires?—The ordinary houses would have fires, but nearly all the newer houses are fitted with heating apparatus as well. I was in Chicago one day in March, and the thermometer was down to 4° at 10 o'clock in the morning, and a wind of 56 miles per hour velocity was blowing. That made it very cold; it is essential in a climate like that to heat the bedrooms.

16672. Do they pay for the heat by meter or by the area?——

16673. (*Chairman.*) It is paid by a rental, is it not?—By the amount of heating surface installed—so many square feet of heating surface installed—and they would pay a rental on that.

16674. (*Mr. Young.*) Did you find from your inquiry that it came out cheaper than it would have done if coal had been used?—I have no doubt it would. The only information I have with regard to that is that they were continually adding fresh houses. At that time there were some 200 connected. I take it that unless there was an economy they would not have taken to it in that way.

16675. (*Chairman.*) It would mean a saving of labour also, would it not?—Yes.

16676. The domestic servant question is a somewhat difficult one in Chicago; is it not?—Yes. There is a question of convenience as well as a question of economy—by arrangement of the temperature of the out-going water at the central station they were able to maintain a fairly even heat under varying outside conditions in those houses by regulating the temperature of the water as they sent it out from the station.

16677. But they pay a good deal more attention in America to heating, warming, and ventilating, than we do here?—A great deal more.

16678. Is it not done mainly by the supply of warmed air, as regards ventilation, and also as regards warming—in their factories, for example?—The factories are dealt with to a great extent by heated air, or steam pipes, mainly, and also by the use of blowers.

16679. That answers the double purpose of warming and ventilating, does it not?—Yes. In many cases they circulate the air in the workshops themselves—not so much by the introduction of fresh air, but by getting the warm air circulated in the workshops themselves.

16680. Do you yourself take the view that the most efficient ventilation is produced by supply rather than by exhaustion?—It is very difficult to give a general opinion, because so much depends upon each individual case as you have to deal with it; but, as a rule, I should much prefer a Plenum inlet system than an extraction system; that is, admitting air by fan rather then extracting by fan. In some cases you may use a system combining the two.

16681. But you have the control over the temperature there also if you like?—Yes.

16682. You can control it more easily?—Yes, you have also the control of the inlet of the air which is in the place. In a dirty town such as Sheffield, for instance, that is very important.

16683. Would you say that Sheffield is a dirty town?—I know of one instance there in the Police Court, where, before a fan was placed, they had occasionally to

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shut the court up, because they could hardly see across the room owing to the thick atmosphere caused by the admission of air, which, on damp foggy days, was heavi y charged with smuts. After that installation was made, and they washed the air they were able to continue the sittings of the Court, I think, on all occasions.

16684. (*Sir George Armytage.*) You say with regard to the temperature of the houses: "The mean temperature of the air in the room when the ventilating back was used was 18·3° higher than that of the outer air, while when the ventilating back was closed the difference was only 9°." Where was your thermometer?—That was a mean of several thermometers—four. The grate in that case was at one end of the room with the bay on one side. One thermometer was placed over the mantlepiece, one was suspended at the centre of the room, one at the extreme end of the room, and one in the bay.

16685. One was close to the fire?—Yes, one was over the fire, on the mantlepiece, one in the centre of the room, one at the opposite end of the room, and one in the bay. That was the average of the whole of the thermometers.

16686. When you speak of fuel here, do you mean coal?—Yes, coal. In the case of the schools it was coke that was used, with a little coal for lighting it.

16687. In those cases of heating schools or large buildings, you have generally spoken of the low pressure water system, have you not—of hot water?—Yes.

16688. If I remember rightly, is not your particular business more connected with the hot air principle? The reason I mention it is that I have called to mind a church in which I think your firm put in a hot air apparatus 25 years ago. Is not that done by means of heating the temperature underneath the floor and send ing it up through gratings?—Yes.

16689. Is that what you are speaking of here when you refer to the steam system in the school?—In B there is air and water; that is a combined system of air and water.

16690. The one I am speaking of was not water?—No, it was air only. In the School B there is air and water.

16691. When you say air and water, does that mean that the hot water pipes heat the air?—No. There is a furnace similar to the one in the church to which you refer, and the air around that furnace is heated; inside the furnace tubular boilers are placed, which heat the water portion.

16692. Then you take the water portion to another part of the building?—The water portion would go to the outlying class rooms, and the central hall would be heated by the warm air in a case like that.

16693. Do I understand that the heat in the central hall is brought up through a grating in the floor?—Yes, practically at floor level, the grating would be in the skirting.

16694. Is not the effect of that to give a great deal of heat over that spot and not so much at the sides of the room?—By colouring that air as it came i you would find that it would go immediately to the roof almost in a column, and then as air is drawn by the ventilation from the floor level, the heat would gradually come down.

16695. Your theory is that that heat goes, up, as it were, in the form of a stream of hot air, towards the ceiling, and spreads itself out. Is that so?—Yes, that is it.

16696. Then does that heat come down again?—Yes; as the cold air is removed by ventilation from the bottom that heat gradually diffuses itself through the whole room. I may say that my father, in designing the heating apparatus for Westminster Abbey, took advantage of that; we placed a large amount of our heating surface (that is done by a combined scheme) in the triforium, where there is plenty of room. That is 70ft. above the floor of the Abbey. That warms the upper air and also prevents any cool draught. The heat, if admitted from the bottom, would go straight to the top. In reply to your other question with regard to the experience I have had with different kinds of heat, I may say that we use both warm air, combined air and water, and steam.

16697. All together?—It all depends upon what the building requires. We do not tie ourselves to any one method; so that I have had experience of all three classes of heating.

16698. (*Professor Dixon.*) Your firm, I think, has put a similar combined mode of heating into the new hall at Owen's College; that is your work, is it not; there is hot air for the big hall, and also hot water for the lower rooms?—In the Whitworth Hall?

16699. Yes.—Yes, that is the system, but that portion of the college was not done by our firm. The Whitworth Hall and the library, I think, is the part which we did not do at Owens College. The other parts of the college, I think, we have to do with. That has been done mostly by our Manchester office.

16700. Yes, there there is hot water and hot air?—Yes.

16701. The big hall, which is above, is heated by means of the hot air, and the lower rooms are heated by hot water?—Yes.

16702. From the same furnace?—Yes, we work the two together. In the case of the Whitworth Hall there are separate furnaces for the warm air and hot water.

16703. I should like to ask you one or two further questions as to the experiment which you have referred to of heating the room. Have you by chance got the actual degrees in your notes?—No, I have not them with me.

16704. May we take it that the outside temperature in one case was 50° and in the other 48°, or something like that?—It was rather higher when it was taken.

16705. 52° or 50°, or something of that sort?—I think it was nearly 60° when that was taken.

16706. Outside?—Yes, it was not taken during the winter.

16707. May I put it, then, at 58° and 60° for the two days?—That was it approximately.

16708. Then the mean of the inside air in the one case would be 67°, and in the other case 78°. That seems to me to be a very high temperature for this to be in use?—It was done just as an experiment.

16709. Merely as an experiment?—Yes. I had not the data in such a form as I considered quite reliable, and I tried to get this test on purpose for this meeting.

16710. Then the inside temperature of the walls is really what I was trying to get at. You say there is a difference of 3°; may we take it that one was 58° and the other 61°, or higher than that?—The thermometer with the bulb close to the wall in the one case registered 10° above the outside, and in the other case 7° above; that is, when the average of the thermometers was 18° above the outside, the thermometer bulb placed close against the outside wall was 10° above.

(*Professor Dixon.*) That would be 70° in that case.

16711. (*Sir George Armytage.*) What was the middle one over the fire and the one over the centre of the room?—The average of the four thermometers, the one in the bay, the ones at each end of the room, and the one in the centre of the room would be 18·3° above the outside temperature; and at that time the inside temperature of the walls was 10° above.

16712. (*Professor Dixon.*) Then I may take it from that that the average temperature of the air in the room was very much above that of the wall of the room itself?—Yes.

16713. At least 8° above?—Yes.

16714. Do you think that the thermometer which you used was sufficiently protected from direct radiation to give you the temperature of the air? Did you protect the bulb at all?—It was just lightly protected by being hung as close as it could be to the wall.

16715. No, I am speaking about the one in the middle of the room; was that protected from direct radiation?—Do you mean from direct radiation from the fire?

16716. From walls, fire, or anywhere?— It was protected from direct radiation from the fire by a shield.

16717. Yes, but not otherwise covered?—Not otherwise covered.

16718. Let us suppose then (I do not suppose it would

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Mr. W. Nelson Haden.

6 Aug. 1903.

be quite correct) that it was giving the actual temperature of the air in the middle of the room. According to that, that air was 8° higher in temperature than the walls themselves?—Yes.

16719. From your experience, do you think that is what, we will say, English people as a rule consider a comfortable mode of heating a room—to have the air in a room much higher than the temperature of the walls?—I may say that this was conducted more as a matter of experiment, and we were dealing with higher temperatures in this case than would be the case in ordinary practice.

16720. I understand that, but I am only speaking of the difference between the room and the walls?—The room had had no fire in it for a considerable time before this experiment was taken. Had there been a continual heating in that way the wall temperature would have more nearly approximated to the air temperature of the room.

16721. Then that means it was not a very good test for the purpose desired?—It was not the best that could be taken.

16722. I was only trying to explain this sentence, which you read in your statement: "The economy in this case due to the ventilating back was perhaps 35 per cent.; that is to say, assuming that the grate without the ventilating back was sufficient for the room, the occupants of the room would have been equally comfortable." I was venturing to suggest that the occupants of the room would have been equally comfortable if the air were simply heated and not the walls—that is to say, if they were heated by direct air and not by radiation?—That would be the same in both cases with the two tests.

(*Sir George Armytage.*) That was really the reason I put the question to you with regard to the church, because the hot air comes up the midde aisle and people are sitting there uncomfortably hot, while those in the side aisle are quite cold.

16723. (*Professor Dixon.*) Is it not your experience that people of this nation, at all events, prefer to be warmed by radiation rather than to have cold walls round them and to be breathing hot air?—Decidedly so.

16724. You would say that that is the prevailing wish of people of this country?—Yes.

16725. Therefore such a system as you are suggesting of hot air being brought into a room is not altogether an ideal method unless you heat up the walls as well?—If this grate was in continual use those walls would become certainly warmer, and as in this case the test on the first day was taken without the back, and on the second day with the back. the temperature was only 3° different—there were 3° difference between the walls on the two days; I think that a portion of the air was absorbed by the walls during the first day, consequently that was carried over to the second day, and therefore I made the allowance in reducing the efficiency to 35 per cent.

16726. Then you wish the Commission to understand that these temperatures were not such as would really be found in a continuous working?—Certainly not. That is why I did not give the actual temperatures, because I thought in this case they would be misleading. I was testing simply for the amount of heat units practically which would be given off by the grate to the room by the one or the other method.

16727. Then you would not propose to heat an ordinary sitting-room mainly by warm air brought in?—The main portion would be by direct radiation from the grate itself.

16728. You would have an open fireplace, in fact, plus the hot air?—That is so—to utilise the heat which would otherwise be going up the chimney from the back of the grate.

16729. Yes, I agree with that entirely, but I do not think I agree with the method of heating a room only by the warm air which is poured into the room from such a double back as you have been describing?—It would not be—the idea of the ventilating grate being the combined method.

16730. Yes, I agree with that. Then you speak of making the air humid—that is to say, you would bring the air over some water?—Yes, a little evaporating process in connection with the air.

16731. Of course, you understand that if the moist air was brought in like that and the walls were really considerably colder, you would have a great deal of moisture on the walls. No one would understand that better?—Yes, you would have condensing, which would spoil your books and other things at once.

16732. Then with regard to the instance which you have given of B, how was that combined warm air and water arranged; were there two separate flows of air and water heating the same room, or was the water used for one room, as in the case of the church and Owens College, which have been referred to, or were they both going to the same rooms?—The schoolrooms were heated by water, and the assembly hall by air.

16733. By radiators, or simply by pipes round the room?—In this case they were pipes.

16734. And the bigger room, or the hall, was heated by air?—By air.

16735. It should be stated that the whole school was heated by a combination of hot air, and so on?—That is it.

16736. They were not combined in any particular room?—No.

16737. (*Mr. Briggs.*) You speak of comparing the consumption of coals, from which comparison you arrive at the conclusion that 57½ per cent., under certain circumstances, would be saved. Have you taken any account of the difference in quality of coal which could be used for central heating?—I have there taken coal such as would be used for ordinary house coal, and in that particular test the coal which they were using for the house was also used in the apparatus. But, of course, with a central plant you could use a cheaper coal—that is, coke; a large proportion of coke could be used.

16738. Or, I suppose, slack—small coal?—Yes, mixed with coke.

16739. But that makes rather a dead fire; it wants continually breaking up; then you would have the disadvantage of more attention having to be given to it?—Yes; what you want is a clear fire.

16740. Take an air apparatus, say for a country house, that people desire to warm during the winter in the corridors, and so on. I suppose a hot-air apparatus there, introducing air into the corridors and different places, would be very efficient?—Whether you are able to use an air apparatus depends very much upon the house; if the house is very compact, with a large central hall, rooms opening from that and bedrooms opening from that again, perhaps on another floor, or a second floor, the air apparatus is suitable; but where you have the case of a long straggling house the air apparatus would not be suitable.

16741. And the form of air apparatus, I suppose, is a coil or something, through which air brought from outside is passed into the furnace, is it not?—Either a coil or a metal furnace.

16742. And that is suitably heated by coke?—That is suitably heated by coke.

16743. Without trouble or attention, I suppose?—Of course, there is very little attention needed—not constant attention, like a fire would require. Of course, in such an apparatus as that you could burn in a house, as is usually done in larger mansions for the gardens, all the sifted cinders that you could get from the grates in the house.

16744. Mixed with the coke?—Yes.

16745. (*Mr. Bell.*) I noticed that you gave an assent to the proposition of Professor Dixon as to the method in which people in this country prefer to have themselves warmed; but surely the people of this country have not arrived at this preference from experience which they have had of various methods such as you have been describing. Is it not rather because they have always been accustomed to be warmed by an open fire grate, and they do not know anything about central heating?—I have dealt with that in my evidence. I said that in England, the majority of the heating of houses being done by fires, many people have no experience of anything else, and in some cases they have had experience of heating where ventilation has not been arranged with it. Then, of course, there is considerable ventilation in connection with an open fire in a room; and if radiators are placed in a room, and no provision is made

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for ventilation, they would find the room stuffy at once. I think a great deal of the prejudice, with regard to heating apparatus in this country, has arisen from that cause.

16746. But in other countries—in America and in cold climates, for instance—it is absolutely necessary to have central heating arrangements and stoves, and not to rely at all, or to any appreciable extent, upon open grates, is it not?—In regard to America I have not so much experience of the houses as I have of offices and public buildings. Of course, with the offices and such buildings as Park Row building, in New York, where you get twenty-six floors of offices, to carry up smoke flues through them would be simply impossible.

16747. In Russia, for example, you could not rely upon fires to warm your houses?—In Russia heating is almost entirely done by means of stoves, often built in fire brick in the centres of the rooms.

16748. I only wished that such a statement should not be made without some qualification. But granting that this system of central heating is absolutely necessary in other countries where the climates are very much more severe, do you consider that it is desirable to extend it in this country, not only with the object, of course, of decreasing the consumption of coal, but do you consider that the living in houses will be brought to be quite as comfortable or even more comfortable than under the present system?—Perhaps I may reply to that by stating to you what was stated to me by a gentleman whose house we heated, putting the heat into every room, including all the bedrooms—a small amount in the bedrooms. He said to me that, although his wife and daughters had been living in a house in town (a country town), not heated, and then afterwards went out into the country into the new house, which we heated, after his experience of the first winter, whereas before he had had the doctor continually about on account of colds, neither his wife nor his daughters had had a cold during the whole of the winter. He said, "I do not know what you have done, but that is the result." His brother afterwards had his house heated, and he told me that another member of his family, who was always suffering during the winter from sore throats, had not had one during the winter. I put it down entirely to the fact that the house was evenly warmed right through, and that the ladies, especially if they were in evening dress, did not catch cold by passing from one room to another in the corridors.

16749. (*Chairman.*) Perhaps they took to sleeping with the window open when the house was warmed?—That I should say was of great benefit to them, certainly, if they did; but Mr. Roundell (Lord Selborne's brother-in-law) also told me once that he certainly would not go into a house that was not heated in that way, after having lived in a house that was.

16750. (*Mr. Bell.*) That improved condition of things, which enabled the family to live there all the winter without colds, was brought about by a consumption of coal something like 50 per cent. less than it would have been under the old conditions, was it not?—Yes. If they had had fires in the bedrooms and had heated them to the same extent, it would have meant about that difference in the consumption of coal; but, of course, they probably would not have fires in all the bedrooms all through the winter, in the same way that they would have the heating from the central apparatus all through the winter.

16751. Quite so, but the general saving of coal would be what I have put to you?—If the same temperature was maintained.

16752. And that would apply, not only to that particular house, but it would apply generally if this system were adopted?—It would.

16753. (*Mr. Sopwith.*) You have spoken of some economies in connection with some of the plant. You said "by the return of the condensed water which in another plant formed 87 per cent. of the whole water required to feed the boilers . . ." Was that from several engines, or how was that 87 per cent. of the water collected?—In that case it was a steam heating plant—the buildings were heated by steam. The water from the exhaust steam was condensed by heater condensers, which heated the water for the supply of baths and such like purposes. The water from the condensation of that exhaust steam heating plant was brought back; the water from the condensation in the steam cooking appliances was brought back, and a portion of that from the laundry—all except that which was turned into the washing tubs direct.

16754. You really had a central condensation plant?—Yes; the condensed water was brought back, as much of it as possible to the boiler house.

16755. And that resulted in 87 per cent. Then you said, "In other plants, where condensing apparatus is provided there is a large amount of heat lost in the water used for condensing." What does that mean?—Of course, for condensing purposes you want to get cold water.

16756. Yes.—That is usually done in mills and such places by cooling ponds, the object of the cooling pond being to get rid of the heat which the water has taken up in passing through the condensers. That heat is dispersed to the atmosphere, on the surface of the cooling pond, and is, of course, lost.

16757. Of course it is lost, but that cannot be helped?—No, unless some use can be made of the hot water.

16758. You said that there is a clear saving in fuel of 19½ per cent. with the use of an economiser. That is rather a large percentage, is it not?—Well, I took that in actual test from plant, one week with the economiser and one week without the economiser, and that was the result in coal.

16759. Do you know what the temperature of the feed water was?—I have not the temperatures of the feed water, because that was taken over a week, and that would be varying considerably.

16760. Would it have to be raised to 212°?—Probably above that.

16761. It would have to be raised to considerably above that to get that 19½ per cent.?—It would probably be raised above that by its passing through the economiser.

16762. You could not give the temperature, could you?—I have not the temperatures for that, because it was taken over a week, and that would have meant taking an average the whole time.

16763. It seems to me to be a larger economy than can practically be effected in raising water from, say, 60° to a little over 212°, taking into consideration the heat of the radiation?—That was taken by actual fuel weighed for a test of seven days in each case.

16764. Could you furnish the figures to us, perhaps not for the purposes of this Commission, but if you can let me have them I should like to see them?—I think I have the figures of the coal consumed.

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THIRTIETH DAY.

Tuesday, 20*th October* 1903.

PRESENT:

THE CHAIRMAN.

SIR GEORGE ARMYTAGE.	DR. LE NEVE FOSTER.
SIR WILLIAM LEWIS.	PROFESSOR HULL.
MR. BELL.	MR. SOPWITH.
MR. BRIGGS.	MR. TEALL.
MR. J. S. DIXON	MR. YOUNG.

The Secretary.
The Assistant Secretary.

MR. W. MACNAB, F.I.C., called; and Examined.

Mr. W. MacNab, F.I.C.

20 Oct. 1903.

16765. (*Chairman.*) Are you a consulting chemist, and a Director of the British Compressed Peat Fuel Co., Ltd.?—Yes.

16766. Have you been occupied for many years with questions relating to the utilisation of peat, and during the last few years have you had special opportunities of studying and seeing processes at work for the production of peat fuel both in Ireland and on the Continent?—I have.

16767. Is your Company now in active operation?—It is not in operation. It was formed chiefly for the purpose of trying a specific process for the manufacture of peat fuel, to see whether it was commercially possible with the processes that were in question. That was tried, and it was found we could produce very good fuel, but with that process we could not produce it commercially, so that the company is still in existence waiting to see what turns up in the way of manufacture. We have accumulated a good deal of experience and knowledge about what can and cannot be done. We thought it was a pity to let the organisation slide, so that it is simply kept alive until such time as we can recommend anything to our shareholders or anyone else to take up.

16768. Is there any trustworthy estimate, or means of obtaining an estimate, of the amount of peat in the British Isles suitable for fuel purposes?—I do not know of any official estimate. One sees a great many statements in books—the *Encyclopædia Britannica*, and various geological books occasionally—as to the extent of the peat bogs.

16769. Do they lie principally in Ireland?—Yes, but there are also considerable bogs in England.

16770. And Scotland?—Yes.

16771. Is the stuff that is used in the place of straw for bedding, the kind of peat which is available for this purpose?—Not for the purpose of fuel: that is generally the top part of the bog where the peat is in a more fibrous state.

16772. I daresay you are aware that somewhere in the neighbourhood of Goole there is a peat bog?—There are very large works there belonging to the British Moss Litter Company.

16773. But that is not suitable for fuel?—Not the top stuff.

16774. Is there anything underneath it suitable?—Yes: some of it is pretty good.

16775. Do you know whether peat fuel has been used successfully for power producing as a substitute for coal?—Yes.

16776. In this country?—There has been no compressed peat fuel used to any extent in this country for that purpose—beyond odd experiments, for instance, in Ireland. Where we carried out our experiments in making compressed peat fuel of course we always fired the boiler with the ordinary cut fuel as cut by the peasants.

16777. Was that in the centre of Ireland?—Yes. I do not think there has been any substantial consumption of it for power purposes in this country.

16778. I think you said that you do not know of any case where the process has been carried out with commercial success in this country?—I do not.

16779. I should like to put this general question: do you attribute that to the cheapness of coal?—No. I think in Ireland the thing should be able to be made at a profit, considering the price of coal there.

16780. I suppose it would not stand much carriage, would it?—Not very much: but my own feeling is that it can be made in Ireland, and that possibly if one of the processes that are worked successfully on the Continent were started there it could be made to pay.

16781. Do you know of any case where it is used for power purposes; for example, in Germany?—Yes.

16782. And in Sweden and Russia?—Yes. A number of the locomotives are fired with it in parts of Russia, and some of the factories have power generated from the combustion of peat.

16783. It is almost essential, to have successful operations, that you should have a period of the year particularly favourable for drying?—Yes.

16784. That lessens the cost, I take it?—Yes, very much.

16785. It would increase the cost if you had to dry it artificially?—By combining air drying and finishing off with artificial drying the thing can be done economically: but in Ireland and in this country, too, there is greater difficulty in doing it than on the Continent, where you have, as a rule, drier weather.

16786. Can you tell us shortly the processes which peat must undergo in order to be available as fuel?—The simplest process of all is the ordinary one which one sees in this country, where the peasant cuts the peat with a special spade in the form of sods, spreading it out on the ground, and stacking it; then when sufficiently dry they use it for burning. In that form it is bulky, and certainly will not bear the cost or fatigue of transport, it crumbles too much. In Germany, and generally on the Continent, there has been a fair success by taking the peat as it comes from the bog, putting it through a disintegrating machine, and then pulping it all up and forcing it through a thing that looks like a gigantic sausage machine, out of which it comes in the form of bricks, which are placed on the ground and allowed to remain there, till sufficiently hard to bear handling, and then stacked. The effect of macerating and breaking up the peat is that when it does dry it contracts very much more than the ordinary sod simply cut out of the bog, and it becomes extremely dense, and in some cases is as desirable fuel as you could have.

16787. That is without any admixture of any other matter?—Yes, without any admixture. There is a variation of that process used where they add an additional quantity of water, regularly pulping it up along with the peat, and allowing it in that form to run into a kind of porous mould, when the water drains away and it becomes like excessively fine mud, which is formed into balls, and that dries excessively hard generally, and burns very well. On the other hand, there is not a very great

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deal of uniformity in the fuel produced in that way, but it is fairly cheap. Then another way to make the fuel is to take it from the bog, and partially dry it by exposing it to the air, thus getting it down to about 50% of water.

16788. What is your estimate of the quantity of water in it as it is cut ?—As a rule, from 80 to 90 per cent.

16789. Of its total weight ?—Yes.

16790. And out of that total 50 per cent. will burn ?—The point is not that it will burn, but that it can be profitably dried artificially. To make peat briquettes it is desirable to have only about 15 per cent. of water in the peat, and when that is expelled by drying it artifically after being disintegrated, then it is put through the special briquette process, and comes out in the form of dense hard briquettes. Made in that way it is a most excellent fuel.

16791. How is the water got out of it ?—By passing it through the various kinds of drying apparatus for example, what they call in Germany the Teller-Ofen or plate drier.

16792. It means the application of heat ?—Yes.

16793. It is not done by any centrifugal action ?—No.

16794. Can it be dried in that way ? Is it sufficiently porous to yield its water ?—In some cases it can. There have been a variety of experiments made for getting rid of the first part of the water by mechanical means either by pressure or centrifugal action. Pressing it between plates has not been very successful except with fibrous peats.

16795. You mean you cannot get the water out of the heart of it ?—That has not been a success. There have been a great number of processes tried for that. The centrifugal action I do not think has succeeded with the really rich finely divided peat.

16796. The finer and richer it is, the more tenaciously it holds the water, I suppose ?—I would not say that, but it is more difficult to get rid of the water by mechanical means when the peat is very fine, because it flows along with the water.

(*The Witness produced two specimens.*)

That more or less is the final result of briquetting peat, and in that form it is a most excellent fuel.

16797. Does this contain any additional material ?—No, nothing but the peat. It contains about 15 per cent. of water. That makes beautiful briquettes.

16798. (*Professor Hull.*) In what part of Ireland was that made ?—Near Tullamore, King's County.

16799. Who is Peters, whose name is on the other sample ?—A manufacturer of peat fuel near Stettin. That is Irish peat.

16800. (*Chairman.*) Sent over for the purpose of getting it tested ?—Yes. I saw the briquette being made there.

16801. (*Professor Hull.*) Is there much sulphur in it ?—Very little. It is extremely good for metallurgical purposes from that point of view.

16802. Is the plant costly ?—For the making of the briquettes it is pretty costly.

16803. It requires a good deal of power, I take it ?—Yes, and as a rule the waste steam from the compressors is used for heating the drying apparatus. What seems one of the difficulties in this country is to get the process on a commercial basis, where you are so dependent on the weather to help you in the first part of the drying. I do not think it is impossible, by any means. I think if one were to adopt such a system as Mr. Peters has—or others—for air and steam-drying the briquettes could be made at a profit. It involves a fairly large capital and wants some consideration before starting.

16804. I take it the peat usually lies away from any of the great centres of population ?—Generally, but not always. I believe there are some extremely favourable bogs in the north of Ireland not very far from Belfast and the manufacturing counties and towns round there. Of course there have been many suggestions to try and utilise the fuel on the bog, such as by making large generating stations for electricity, which could be distributed more easily than fuel.

16805. But none have come to any practical success ?—Not yet.

16806. Do you know at all whether peat in Ireland, for example, is used for any manufacturing processes ?—Not except locally; where there is a small industry it may be used for power purposes.

16807. Mixed with coal ?—Yes, or alone. For instance, in King's County, where our experiments went on, all the steam threshing machines or any things of that sort were invariably fired with peat.

16808. Have you any sort of estimate as to what the cost per ton of labour is in connection with this larger sample which you produce ?—I believe this briquette could be made in Germany for about 6s. or 7s. a ton at the works.

16809. That excludes the cost of the material, to start with ?—I think not—that includes the cost of the material, the cutting of it, the air-drying of it, the artificial drying of it, and the compressing of it.

16810. I was thinking of the land off which it was taken. I take it I could not go, for example, and put a plant down without making arrangements with the owners ?—Certainly not. In several places in Germany the land belongs to the people who make the peat fuel. In Ireland I think the habit is to let it at a royalty, which is a small one of 3d. per ton, or something like that.

16811. (*Mr. Young.*) It means labour cost ?—Yes. The whole difficulty is the question of drying—getting rid of the first part of the water.

16812. (*Chairman.*) Could you say at all how it compares with coal as regards its calorific value ?—The actual calorific value varies, but I take it to be on an average about two-thirds that of coal.

16813. (*Sir George Armytage.*) The same weight ?—Yes.

16814. Or the same capacity ?—No, the same weight. I have seen a number of statements—I have not had an opportunity of verifying them or comparing them, but I think they are worthy of credence—that such fuels as these have been used for firing boilers where formerly the coal had been used, and they have kept up the same steam and done the same work with approximately the same consumption.

16815. (*Chairman.*) The same weight of fuel ?—Yes. It is a little paradoxical, but on the other hand I think it is explained in this way, that this peat requires much less draught for combustion, and not so much air, and consequently the heat that is generated by the peat, although less than in the case of coal, is really better utilised.

16816. That is to say, one and a half tons of peat at 6s. would represent a ton of coal at 9s. ?—Yes.

16817. And in bulk it would be of greater cubical contents than coal ?—No, in this form it is very nearly as dense as coal.

16818. You would have the carriage on 30 cwt. instead of on a ton ?—Yes.

16819. Have you tested at all the evaporative power of peat fuel as against coal ?—No, I have not had the opportunity of making those comparative tests.

16820. With regard to any admixture of other materials do you discard that as being impracticable or as being of little value ?—I do not think they are necessary.

16821. In the cases within your knowledge of the manufacture of these briquettes in Germany and Sweden and other places, do they use no tar, or any mixture of anything ?—No, there have been a number of proposals for mixing all sorts of things with the peat, but peat is so far different from very fine coal that it will briquette by itself. These briquettes are made by forcing peat through open tube presses where a certain amount of heat is generated, and in that way peat combines quite well.

16822. If you put it on a fire, would it disintegrate more quickly than coal ?—I do not think so. It makes a most excellent and delightful fire. It is an ideal sort of domestic fire for appearance.

16823. Does it flame ?—Yes. It gives practically no smoke, and gives a great deal of heat. Everyone who

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Mr. W. MacNab, F.I.C.

20 Oct. 1903.

has seen peat burning in these briquette forms is delighted with it. It makes a very nice fire, indeed.

16824. Have any briquettes been sent to this country from Germany for sale?—They have come merely as samples—nothing to sell at present.

16825. (*Professor Hull.*) Does the burning of those briquettes produce the peculiar odour of smell which peat produces?—Yes.

16826. On approaching an Irish village, when you get within about half a mile you can smell the fumes?—Yes, there is just the regular peat smell from this, too.

16827. (*Chairman.*) Is any particular sort of boiler or grate required for the burning of these briquettes?—The chief thing required is to have much closer fire bars, because ultimately when it gets small it falls into very fine ashes.

16828. In speaking of these bogs, is the whole of the bed of peat available for the purpose?—Not always.

16829. The bottom or the top, or the middle?—As a rule the very top is too fibrous, and that is generally scraped away, and sometimes used for peat moss litter. Then as you go down it very often improves in quality; that is to say, the carbon constituents rise, and it has a rather higher calorific value; and sometimes when you get too low down you begin to get it more mixed with mineral matter. But in some bogs we have seen we have had most uniform composition for a great depth. Of course, there are bogs and bogs from the fuel point of view; some contain a very high percentage of ash; others, again, go down to 2 per cent.

16830. In estimating the waste of material in producing this fuel, you would have to estimate for laying aside a portion of the top and the bottom of the bog in every case?—You could simply let the bottom portion remain when you found it was not suitable. The top is sometimes very useful for spreading over and helping to make a drier bottom for the peat to rest on.

16831. Are there any bye-products coming from any of this?—Not particularly. In the combustion there is a small amount of nitrogen sometimes in the peat, which would probably form ammonia.

16832. Do you think it would be possible, supposing the manufacture to be mechanically successful, to export peat, say from Ireland to England, to compete with coal?—I do not think it would ever compete with coal anywhere near the coal pits.

16833. Not for power purposes?—For power purposes I think it would compete very well. For instance, this sort of fuel, I should think, would be excellent for steamers, especially where you wanted absence of smoke. It is very compact, and it can be very closely packed in any form of briquette.

16834. But I gather you think, for example, that supposing London could be supplied with that, it would be cleaner than coal?—Infinitely cleaner, both in the handling and in the matter of smoke. There is a very large quantity of peat down in Dartmoor—some huge bogs of great extent—and some experiments have been made there with a view to utilising them, but they have not resulted in a commercial success.

16835. The addition of oil or petroleum, or material of that description, would rather increase the smoke, would it not?—It would.

16836. You do not contemplate any admixture of that kind?—I do not think it is necessary, unless you could get it at anything like as cheap a price as the peat. Of course, it would enhance the heating value of the briquette to put in some oil.

16837. With regard to briquette presses, do you think we have made as much progress in this country as they have abroad?—Not for the peat briquette.

16838. Would you say that the briquette business has been stimulated in Germany, for example, by reason, say, of the inferior coal or the high price of coal?—I think so, largely. The coal briquette is made generally with an admixture of tar; the mixture is heated and compressed in a closed press; that is a very large industry all over the Continent and also in this country, in South Wales.

16839. You are now speaking of the coal briquette?—Yes, the coal briquette made with the admixture of tar. In Germany they started briquetting the lignite or brown coal, and they used a different press, because they found that they could make the briquette without mixing any other substance with the lignite itself. There they began with these so-called open tube presses. They have brought them to a very high state of perfection. They have been adopting the same press for making peat briquettes with very great success.

16840. It is first of all disintegrated?—First of all air dried, and then disintegrated; then in the disintegrated state it is dried by steam or direct heat, and then compressed into such briquettes as I have shown. I think the last word has been said about briquetting presses in Germany. They have them thoroughly well done. In Canada there has been a great deal of work going on. I have not seen any of the work there, but I have heard a great deal of it. They seem to have obtained quite a commercial success recently in one or two places in the province of Ontario.

16841. Is that because they are far away from the coalfield?—Yes, and what has given a stimulus to it has been the coal strike in America. They have been working away at peat for a great number of years, and this strike gave them a great stimulus, and they seem to have got over the initial difficulties very well.

16842. Have they any laws in Canada with regard to smoke, anything like as stringent, for example, as those in New York?—That I do not know; but I do know that the population have been accustomed to the use of smokeless and clean anthracite, and peat is very smokeless and clean.

16843. It is almost necessary where they use stoves?—Yes; it is a great help, undoubtedly.

16844. The soft coal is much more offensive if used in stoves?—Much more. In Canada they seem to have made great progress in the method of gathering the peat, and that, I think, might possibly solve the difficulty with some of the schemes over here; they have various devices; in some places they have a big harrow sent over the ground after removing the extremely fibrous portion.

16845. Do they cut the top portion out?—Yes, they remove it.

16846. By a sort of plough?—Generally a sort of plough; they just tear it off at first, and then, when they have an even bed of peat, they harrow it about a couple of inches. They find that dries down to about 40 per cent. in two or three hours in decent weather. Then that is scraped away, and the harrow sent over again.

16847. And the process is repeated?—Yes.

16848. Would you say that the admixture of oil, for example, would render it in any way unnecessary to expend less money, supposing the drying to be artificial? In other words, could you, by the admixture of oil with the peat, make a briquette which, although it contained more water, would still, for the purpose of firing, and for the purpose of calorific value, be as good as the other, which contained less water, but contained no admixture?—I do not think it would, for this reason: that with a large quantity of water, or a very much larger quantity than, say, 15 per cent., briquettes do not hold together well.

16849. Even with the admixture?—I do not think that would be a sufficiently binding mixture.

16850. (*Professor Hull.*) I suppose in Canada they are much more certain of periods of extreme heat and dry weather?—Yes, that is the case. It makes one a little chary of just assuming that you would get as good results here by their system. On the other hand, they have the labour question very much minimised and simplified by their way of working. In one place they have a large electrical digger which travels along and turns out extremely good work.

16851. The electric power being generated by the power from the peat?—Yes. It is a huge kind of carriage with very wide wheels, which travels along, and has a long digger like the arm of a pick.

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16852. Really the climatic conditions of Great Britain do not lend themselves to this?—They undoubtedly put very serious difficulties in the way. But I must say I feel that peat will be made into a profitable fuel here yet.

16853. It would be difficult, in such a so-called summer as we have just had?—Quite so.

16854. (*Professor Hull.*) What is the best drying time in Canada?—May, June, July and August, certainly, are extremely good months.

16855. (*Chairman.*) Does the extreme cold help them?—No, cold is a disadvantage, because if the frost gets into the peat it spoils it to a large extent. It ruptures the cells in a way, and they do not seem to combine so well—it gives off the water easily, but the peat afterwards does not seem to briquette so well.

16856. (*Sir George Armytage.*) Where is this British Compressed Peat Fuel Company working now?—They are not working at all now.

16857. Have they worked in Great Britain?—They have worked in Ireland.

16858. And in Ireland only?—Yes.

16859. But it was not a commercial success?—No.

16860. Are these fuels, and any others you have seen abroad, generally made in the same shapes as those you have produced, or in other shapes?—The average shape that is made on the Continent is a briquette about the length of Peters' briquette here.

16861. Like a small brick?—Yes.

16862. Square corners, or rounded off?—Generally rounded off. Sometimes when made for boiler purposes they are divided into two.

16863. Which is the best shape, and mostly used, for the purpose of getting a draught of air through?—The square shape.

16864. This special shape is extremely suitable for the German stoves?—Yes.

16865. Did I understand you, as regards bulk, that a ton of this is about equal to a ton of coal?—Yes, about the same.

16866. But as to its calorific value, 1½ tons of this peat fuel go to about a ton of coal?—Yes, that is so theoretically.

16867. (*Chairman.*) You would not say a ton and a-half of peat would be as good, for example, as a ton of smokeless coal from South Wales?—No.

16868. (*Sir George Armytage.*) May I put it in this way. How much of this fuel would it take to evaporate the same amount of water as a ton of Welsh coal?—I could hardly give a definite answer to that. Actually the number of calories in these peat briquettes is about 5,000, on an average.

16869. (*Chairman.*) How does that compare with coal?—Coal has 7,000 to 9,000.

16870. (*Sir George Armytage.*) It is about 1½ tons to a ton?—I think it is but fair on behalf of peat to say that I have heard statements made by people who, I think, are quite entitled to credence, that as a practical result you do not require as much fuel as you would expect from the calorific content of the peat—that you utilise more of the smaller number of calories which are given out on combustion, and you utilise those better than you do the larger number that result from the combustion of coal.

16871. When this form of peat has been made abroad with success, what is the cost per ton for machinery and labour in making it, quite apart from the value?—I think about 6s. per ton.

16872. I understood you to say that that was the selling price. That is the cost of making it?—Yes, produced at the factory—about 6s. per ton.

16873. (*Dr. Le Neve Foster.*) To whom do most of the peat bogs in Ireland belong?—Some of the larger bogs belong to the large landed proprietors.

16874. They do not belong to the Crown?—I think not. I do not know particularly about it.

16875. Have any surveys been made of the bogs?—That is a matter which I do not know. In some cases there have been surveys made, and I have seen a Report, published I think about 1853, by Sir Robert Kane; there was a Commission appointed to inquire into the peat question in Ireland, and I think there are some data given there as to the extent of the bogs.

16876. But you are not aware of systematic surveys being made by borings at regular intervals in the way in which they are made in Russia, for instance?—No. In small individual cases I have heard of it being done, but I do not know of any systematic surveys made in that way. Of course, that is a matter as to which it is extremely desirable to obtain information.

16877. It would be quite impossible without that to form any estimate of the quantity of peat existing in Ireland?—Yes, that is the only real solid way to go to work—to get the area and then put down the borings.

16878. Have you ever seen the work that has been done by the Russian Department of Agriculture?—Yes. Much of it is most admirable.

16879. Such surveys of theirs as I have seen have been most thorough and complete, enabling one to form an estimate of the extent of the bog.—Yes.

16880. But with regard to that kind of thing, you are not aware of anything having been done in Ireland?—No, I am not aware of it. I cannot say that it has not been done, but I do not know.

16881. With regard to peat on the land of private landowners, it would be the landowner's business, in your opinion, I suppose, to do that work?—Well, I hardly think so, for this reason: I think it is going to cost a good deal of money to start the thing. At first there was an idea that little presses and things could be fitted up, and that every man who had a bog could make fuel for himself and his own immediate surroundings; but what I have seen of the industry and of peat manufacture leads me to think that the only way to do it with success would be on a large scale—to obtain control of a number of bogs and start a large works.

16882. And you would not, I take it, expect the Government to make surveys of peat upon private lands, would you?—I do not know that I have specially considered that. I think that, undoubtedly, peat is an asset to this country, and that it would be an immense help for any commercial people who were going to take it up if they knew a little more about what the thing really was.

16883. But ought not the landowner, to whom it belongs, who wishes to make use of it, and who would be the only person to gain by it, to make the necessary surveys, and not the Government?—Certainly he would add to the value of his possessions if he could tell any one definitely the extent and character of the bogs which were on his land.

16884. (*Chairman.*) Is there any information shown on the Geological Survey Maps?—I do not think there is very much.

16885. (*Mr. Teall.*) We map the outlines of the peat in Scotland, but we do not make borings.

16886. (*Chairman.*) What is done with regard to Ireland?—(*Dr. Le Neve Foster.*) The area is marked.

16887. (*Chairman.*) Do you know at all whether the area is shown on the Geological Survey Maps in Ireland?—I think in Ireland about a seventh of the area of the island is shown as peat bog land.

16888. Is that shown on the map?—I think so, but I think the great lack of information is as to the depths of the bogs.

16889. (*Dr. Le Neve Foster.*) The knowledge of the area is of little use unless you know the depth?—Certainly. In some cases it is very, very deep. It has been known in individual cases to be fifty or sixty feet in depth, but I think more often it is about five to ten feet.

16890. I take it that the work of making these borings is pretty rapidly and inexpensively performed?—It is not very costly.

16891. Do you know of any cases in Ireland where landlords have plans of their estates with borings showing the area?—I do not know.

16892. Is there anything better that you know of for determining the quantity of peat than the plan which is

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Mr. W. MacNab, F.I.C.

20 Oct. 1903.

adopted by the Russians ?—I think that is by a long way the most conclusive—to measure out the areas on the surveys and then make the borings at systematic and reasonable intervals, and then find out how the thickness varies. At the same time, with the boring machine you get the opportunity of seeing the quality of the peat.

16893. Is that done in Germany as well ?—Yes, that is done by the people who are working the bogs, but I cannot say whether it is done at all by the State. Last year, I think, a special Department was formed by the Government to study the question of peat.

16894. That is by the German Government ?—Yes.

16895. Does the peat there belong to the landed proprietors, or to the Government ?—I think to both; in some cases to private proprietors.

16896. Does some Government Department examine the peat deposits on the land of private land-owners ?—That I do not know, but they are doing everything possible to facilitate the use of peat lands, and in part of North Germany I believe those lands do belong to the Government.

16897. Do they belong *qud* peat, the peat being a substance belonging to the Government, or do they belong to the Government because it is Crown land or State land ?—I think in that case because it is Crown land.

16898. But in the ordinary way, the peat would belong to the freeholder ?—Yes.

16899. Although coal might not belong to him ?—I am not quite sure about that.

16900. Is peat considered to be a mineral by the Germans ?—I rather think it is.

16901. It is by the French ?—Yes. It is generally so described, I think.

16902. You were speaking about locomotives in Russia being worked with peat. Are they being worked with compressed peat or ordinary peat ?—I think it is neither; it is by what they call the "Press-torf"—the stuff I described, put through a large sort of sausage-machine, and then allowed to dry and contract, when it becomes very hard.

16903. Not compressed peat ?—Not exactly in the ordinary sense. It is kneaded and disintegrated by a set of knives, and then forced, by slight compression, while in a state of dough, through an aperture which is generally in the shape of a brick. It comes out in a long, rectangular form, and is cut up into bricks. I have seen specimens shown by the German makers of a form of apparatus, which were, I think, denser than this sample I have here. They were magnificent specimens.

16904. That was done with very little compression ?—Yes, the stuff is made in the form of dough and then allowed to dry, and it shrinks and gets extremely dense. But when I saw those machines at work in the field, although some of the specimens were undoubtedly magnificent, there was a considerable variation in the quality and the density.

16905. (*Chairman.*) What is the length of the tube through which it passes ?—It is perhaps a couple of feet. There is very little pressure required; there is no compression in the sense that this sample is compressed.

16906. (*Dr. Le Neve Foster.*) It is like the operation of a brick machine ?—Yes, it is pugged up and then it is shoved through.

16907. It acquires its density by shrinkage, and not by pressure ?—That is so. The fibres are broken up and the water escapes more easily and the stuff shrinks closer.

16908. That is by simple contact with air—not with hot air ?—No, open air. Only it does not produce anything like as regular a form; some parts are not so dense as others; the consequence is you get the sods or the bricks in a very variable condition; but it is undoubtedly a great improvement on the ordinary hand-cut peat.

16909. I did not quite gather what you considered to be the cost of briquetting in making the compressed peat. You spoke about 6s. or 7s. per ton ?—Yes.

16910. As I understood, 6s. or 7s. per ton would cover the total cost—that is, digging and everything ?—Yes.

16911. What would the briquetting alone cost ?—I think it is pretty generally accepted that it costs about 3s. per ton to cut the peat and to handle it on the moor, so that it gets air-dried down to about 40 per cent of water; consequently, the remaining handling, artificial drying down to about 15 per cent. of water, and briquetting, cost about the other 3s.

16912. What pressure are they using in the briquette process ?—They are using, I think, about 15 tons per square inch.

16913. You have shown us a peat briquette from the North of Germany. Is not that briquette rather larger than the ordinary brown coal briquette which they make near Bonn ?—No, I think it is very much the same size as the brown coal or lignite briquette. I have seen the factories all round about Cologne, also, where they make the brown coal briquette.

16914. Then it is larger than they were making some ten or twelve years ago ?—Perhaps; it is the usual form for domestic use all over Germany. Then they sometimes have practically the same press, but the plunger has recesses in it so that you get three sizes; it comes out in three bits that are perhaps more or less three inches square.

16915. Do these peat briquettes stand knocking about as well as the brown coal briquettes ?—Yes, they stand handling very well. I have watched them packing both the brown coal briquettes and the peat briquettes, transferring them from carts into trucks and so forth, and they seem to do it very easily and very rapidly; they catch up a number together as you would a number of books and lay them down, so that there is no throwing about at all.

16916. Is there any manufacturer of peat briquettes in Holland ?—Yes, there is the Griendstveen Moss Litter Company, who have gone in recently for briquette making on the same principle as that.

16917. And successfully ?—I believe so. There they use partly air drying and finish up with artificial drying and then making the briquette. I have not seen the place but I have heard about it.

16918. What do you think is the reason that they can be made successfully there and that they cannot be made successfully in Ireland ?—My own feeling is that they could be made successfully at the present time.

16919. If it were done on a larger scale ?—Our concern was formed to try a special process and the process broke down—it would not work commercially. But I do think that if we were to start anew with the knowledge that we have gained, and with what we have seen, and with sufficient money, we could make a success of it in Ireland even now in the present state of things.

16920. Is there any business to be done with peat charcoal ?—Yes, I think there is. It is undoubtedly an extremely suitable fuel for metallurgical purposes on account of its freedom from phosphorus and sulphur.

16921. Do you get any bye-products from the manufacture of it ?—Yes. There have been a number of trials made, some small trials in this country and some larger trials round about Oldenburg in Germany.

16922. Is there much use for it ?—For metallurgical purposes there would be a considerable demand, but as yet I do not think it can be said to be a commercial success.

16923. Is there a process on the market called the "Electrical drying of peat." I have heard something about that. *See Appendix VII.*

16924. What is it ?—I hoped to have seen it at work yesterday, but that was put off just at the last moment, so that I have not actually seen that process. I have read a circular which Mr. Russell was good enough to send me, and all I can say is that it reads exactly like a further development of a process which I saw tried some months ago here in London for drying peat electrically.

16925. What is meant by drying it "electrically?"—So far as I gather, they take the peat as it comes from the bog and put it into a centrifugal machine, whereby the percentage of water is largely reduced.

16926. Then in reality it is simply the old process of drying with a centrifugal machine driven electrically.—

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No, that is the first part of the process. They get rid of the first part of the water by the centrifugal action: then the peat is put into boxes, I think, with perforated bottoms, or it is kept in the same cylinder but there are poles attached and the current is sent through it. The wet peat conducts very well, there is no doubt, and it gets warm and gives off steam, and with care the peat can be dried. When I saw it, the amount of power was out of all proportion to the result obtained, and there was great danger of it firing in the neighbourhood of the poles; but they may have overcome that. I cannot criticise that, because I have not seen it.

16927. You have spoken about using peat briquettes for steamers, and you said that they would be advantageous from the point of view that you would get less smoke. Would not the peat fuel occupy very much more space in the bunkers?—No, I do not think it would, because in the first place in this form it is very nearly of the same specific gravity as coal, and owing to its being made into uniform briquettes of a nice shape it can be packed away so that there is very little space lost.

16928. You can stow it well?—Yes, so that I think that might possibly compensate for having to use an actually larger quantity.

16929. Would it be as smokeless as the best Welsh coal?—I think so. It is extremely smokeless as far as I have seen.

16930. (*Mr. J. S. Dixon.*) Can you tell us what cubic measure of peat would be equal to a ton of briquettes? Supposing you know the area of a peat bog and the thickness, and you know the cubic capacity of that bog, what yield would there be of briquettes in proportion to the cubic capacity of the bog?—I cannot give it to you quite off-hand, but I think we may get at it in this way: it is taken generally that a cubic metre of the peat in the bog, that is to say, with 80 per cent. to 90 per cent. of water, weighs about a ton—1,000 kilogrammes. The yield would be about a fifth.

16931. So that in computing the amount of peat in a country, you would treat only 20 per cent. as the yield in fuel?—Yes, something like that.

16932. Have you any analysis of these briquettes, giving the fixed carbon, ash and water?—Yes, I have analyses. Might I send them to you?

16933. I think it would be very desirable to have them; also the calorific power in evaporating per pound of water?—I can give you the analyses, and I can give you the number of calories in the peat from actual samples made—I have the data.†

16934. That would be very valuable information?—I have not any data here from experiments I have actually made, or that I have actually seen, as to the actual evaporative power of the peat.

16935. We can only judge its value as a fuel as compared with coal by such information as that?—That is so. Some reports have been sent to me of experiments where it has been tried as against coal, and has come out very well indeed in the practical result, although theoretically it is not such a heat giving body.

16936. You spoke of an open bar compressor for making these briquettes. Could you describe how it is worked?—It is an open tube. It is done in this way: there is a horizontal channel made in the form generally of these briquettes, about 8 or 9 inches wide and about 3 inches deep, and into that a piston fits pretty closely; there is a hopper standing above that and the dried and powdery peat falls in there: they generally start the press by putting in a block of wood to make the pressure in the first instance; then the plunger comes behind, squeezes some of the ground peat against this block of wood, and finally drives the whole thing forward.

16937. Is that peat dry?—Yes, dried to about 15 per cent. of water.

16938. I understood that that was the wet peat and that this was a process of drying?—No, that is merely a process of compression. Then each stroke, once the plunger is started, forms a briquette such as you saw.

16939. Generally you consider that the peat in this country is a practical source of power as against coal?—Yes.

16940. You think it is a source which we can take into consideration as one which probably may be used to supplement or save coal?—Yes, certainly, I do.

16941. That would depend, of course, to a great extent upon the price of coal?—Yes, no doubt.

16942. If coal were to rise in price probably this industry would be given a lift forward?—Yes, very much indeed.

16943. I expect that in times of dear coal we shall hear most about this industry?—Well, I would go farther than that; there has been much more systematic work devoted to peat in the last four or five years than has been done before; so that I think the endeavours have come to stay, and that we shall ultimately get some solid result from it.

16944. (*Mr. Teall.*) I think you said that you had no great belief in the future coking of peat?—I should hardly like to say that. There is a good deal of trouble in the coking of peat, but if one could produce these briquettes cheaply enough I think one could produce very good coke.

16945. Do you know anything of the Ziegler process?—I have heard a good deal about it. So far as my information goes that has not been a great success.

16946. You do not know of its being a success anywhere?—No.

16947. Can you say whether in that process they deal with the peat as it comes from the bog in a wet state and dry it artificially?—Yes, it is partly dried artificially.

16948. But do they deal with the peat when it has 80 per cent. or 90 per cent. of moisture in, or must it be air-dried?—I think it must be air-dried before they begin.

16949. But you have no actual experience of that?—No, I have not seen that.

16950. You have probably had some reports before you as to the amount of peat, say in Ireland or Scotland?—Yes.

16951. But they were not sufficiently detailed for practical purposes?—No, they certainly were not definite. But we knew from general information that there was ample peat there to keep going any ordinary Company that might be formed to make fuel.

16952. You could not give this Commission any data on that point, which you have collected, and which might be useful to us?—No, I am sorry I have not any data of my own collecting that would be of any use.

16953. You would not care to give the Commission any information on that point?—No, we have not really anything which I think would be of value in that way.

16954. I suppose that any comparatively small isolated patches of peat, such as occur in Scotland, for example, would be very difficult to treat by any process?—Oh, yes, if they are isolated, undoubtedly.

16955. You require a very large amount of peat close at hand?—That is so, because in the briquetting works undoubtedly you have very heavy machinery and you would need a pretty permanent building to support it, and unless you have easy means of transporting the raw peat by tramways or canals you would run away with all the profit.

16956. (*Chairman.*) I gather what you mean is that inasmuch as you would have a very large, and probably a very costly plant, you would require a large area to feed it?—Yes, quite so.

16957. It would not pay otherwise?—It would not. There was a great talk when we first began our work about our going to do a splendid thing by getting a small apparatus, costing a few hundreds of pounds, and that one would have little peat factories all over the place, but that seems to me to be quite impracticable.

16958. (*Mr. Teall.*) It must be done on a large scale?—Yes.

16959. (*Mr. Briggs.*) Is there much deterioration or any deterioration of the briquettes by exposure to the air?—No, I think not.

† The analysis of a briquette such as those exhibited is as follows:—Moisture 11·30 per cent; ash, 8·02 per cent; calories per gram in sample, 4357; calculated without moisture and ash, 5401.

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Mr. W. MacNab, F.I.C.

20 Oct. 1903.

16960. So that they are better than coal in that respect?—Yes, I do not think there will be any serious deterioration. It is a curious thing that peat is a kind of cellulose substance, and to that extent it has what you might call a "water of condition" like cotton, so that if you overdry it, it will always take back about 15 per cent. of moisture from the air.

16961. It is absorbent to that extent?—Yes. On the other hand, if you allow it to dry it will dry down to 15 per cent. in the air, but not much beyond that.

16962. You have spoken about the use of peat in Holland, and I know that in the north of Holland peat does compete with coal for power purposes. Can you tell me whether that peat is used manufactured into briquettes or whether it is used in the air-dried form?—I think it is used very largely in the briquette form.

16963. I am speaking of the neighbourhood of Groeningen on the North-east?—Yes. The Griendstveen factory is at a place called Helenaveen, I think, but I have never been there. That is a very big concern. They have a very large and very systematic way, as I understand, of gathering the peat, and that, of course, is quite an important point.

16964. What would you consider to be a good average depth of bog such as would be well worth exploiting?—Bogs that I have come across, and which I think would be extremely suitable for the purpose, run from I think six to ten feet, but I do know that in Canada they have a bog where they are working successfully with only about two feet of good peat.

16965. (*Mr. Bell.*) You say that more systematic efforts are going on in this country now in the attempt to produce peat, and that the industry, so to say, has come to stay?—Well, it has hardly got to that state yet, perhaps; but there has certainly been much more effort made in recent years to make suitable fuel from peat, and many people are still working at it, and progress is also being made both on the Continent and in Canada.

16966. But can you give us any instance in this country where it has been a successful industry and where successful efforts have been made?—No, I cannot.

16967. Nor in Ireland?—No.

16968. Is anything being done now in any part of Scotland or Ireland? Your Company has not succeeded in making it a success?—No.

16969. Are efforts being made by other Companies?—I read in the papers a few weeks ago that there was a Scotch Peat Fuel Company.

16970. At Dumfries?—At Dumfries, I think, which was said to be going to do great things.

See Appendix VII.

16971. I have heard of that Company being very confident of success. I thought, perhaps, you might be able to give us some information about it?—No, I have not any information about it. I do know that there is an immense amount of confidence about the success of peat schemes.

16972. Do you know anything about the quantity of peat produced in Germany and in Russia?—I saw some statistics which were given in one of the American Consular Reports. I cannot say off-hand. There is quite a large amount in Russia; Russia comes first, I think.

16973. You do not know the quantity, but do you know that part of Russia where peat is used for locomotive purposes: is it in districts far away from the oil-fields, or is coal, timber or oil so dear in that district that they have recourse to peat?—They have some very large peat works in the neighbourhood of St. Petersburg; of course that is far away from the oil and comparatively far from the coal. On the other hand, it is right in the wood district. They seem to compete there quite well with wood for locomotive purposes and for heating purposes. They have also a compressed peat works at a place called Ivanovka, near St. Petersburg.

16974. (*Mr. Young.*) Have you any idea as to the cost of a plant to make about 5,000 tons of briquettes per week?—That is a big order. I have one or two data with regard to considerable smaller installations than that. For the production of about 700 or 800 tons per week of briquettes you could certainly put up a factory for about £20,000 to £22,000.

16975. What do you suppose they could put it on to the London market for per ton?—I do not think, so far as my information goes, that you could reckon on producing peat briquettes at the bog for much less than 5s. at the outside—6s. or perhaps 7s.—say 6s. per ton.

16976. But how much to place it on the London market?—I do not know what the cost of transport would be. Of course, from Ireland it would have to come by ship. We never got to that stage.

16977. Is the odour very objectionable in using peat briquettes for domestic purposes?—No, I think not. You hardly notice it at all unless any of the smoke gets blown out into the room.

16978. I think Professor Hull asked you whether you could not smell the peat when you got within half-a-mile of where it was generally used in villages?—I suppose outside you would. The smoke going up the chimney would more or less have a smell, but in a room, burning it in an ordinary grate, you do not smell anything unless accidentally the smoke comes out or the fumes come out into the room. I take it that there would be up above the chimney much the same smell as there would be in the ordinary way of burning peat.

16979. You do not think it would saturate the furniture in a house?—I do not think so.

16980. Have you been in houses where peat has been constantly used for fuel?—Yes, I have been in many gentlemen's houses in Ireland where they burn nothing but large blocks of peat of the ordinary sort, and I never noticed anything objectionable there. It is quite different from the case of the ordinary cottager's house. With these briquettes I think the combustion would be rather more perfect and that there would be possibly less smell, and I do not think there would be any objection on that ground.

16981. I think you have said, in reply to Dr. Foster, that you thought the Government should defray some of the cost of boring, and that the expenses of doing that should hardly be left to the landlord altogether?—It seems to me it is a sort of national asset that would be utilised some day.

16982. In the case of the Government undertaking to bore and explore for peat, would you give the Government a claim upon some of its value?—Well, it is so hard to say what would be the kind of economic conditions under which the Company would have to work; because when a matter is left to private enterprise a Company starts with the object of making some money out of it, and if it is not too hard pressed by landlords or by the owners of the peat or by the Government, of course it might do pretty well. Still, the point is that peat is of such a comparatively small value when it is made into fuel and requires such a great deal of handling before it can be made ready for the market, that it will not stand very much either in the way of royalty or any other kind of tax.

16983. But it approaches very nearly to coal in its actual use I understand?—Yes.

16984. Therefore it has a considerable value?—Yes, it has.

16985. And it will have more and more value as the coal becomes exhausted?—Yes, that is perfectly true. One may say there is a certain amount of work to be done upon coal to get it out, but in the case of peat you have to handle, in the first instance, such an extremely large quantity of stuff. For instance, the peat when taken from the bog only contains about 20 or 30 available parts of fuel, and requires a lot of handling, so that the actual expense becomes very high, although you get it for very little.

16986. If the landlord or landowner will do nothing to ascertain the extent of the peat bogs in order to induce capitalists to go in and work them, and if the Government do the work instead, do not you think that the peat practically belongs then to the nation which undertakes the expense of discovering anything of value?—Well, some consideration in regard to such matters, no doubt, would be needed.

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16987. (*Dr. Le Neve Foster.*) Is not the favour with which briquettes for domestic use are looked upon in Holland largely due to the fact that they are so clean ?—I think so. That is found everywhere, both on the Continent and here in the cases in which we have had some small experience of it, where we have made small lots and circulated them amongst people—everyone has been delighted with them—it is a clean thing, and you can pick it up with your hands and put it on the fire and you do not soil anything.

16988. I gather that the peat briquette would be quite as clean as the brown coal briquette which is so largely made in Germany and exported in Holland ?—Certainly, quite as clean. I think a trifle cleaner.

16989. (*Chairman.*) Have you any knowledge of the cost of plant required for a colliery ?—No.

16990. Because it looks as though the cost of a peat plant would be as high as the cost of a colliery plant. Did I gather your answer correctly—that a plant which you estimated would make 700 tons of peat per week would cost £20,000.—Yes.

16991. That would mean that in order to make 10,000 tons per week you would want a plant which would cost nearly £300,000 ?—Yes, it is a big thing.

16992. Therefore we get to this position *quâ* peat, that the capital outlay would be as large as for a colliery, the labour cost per ton for producing the article would be considerably higher than the labour cost per ton for getting coal, and the product when got would be two-thirds of the value of the coal. Now where is the economical advantage of pursuing the manufacture of peat fuel under those conditions—so long as you have any coal, of course ?—I do not think it can ever compete actively with coal near coal mines.

16993. (*Mr. Briggs.*) May I ask a question with regard to the relative calorific value of a briquette of peat and a briquette of lignite. Are they much the same ?—As a rule, I think, taking fairly good peat, a peat briquette is rather better than a lignite briquette.

16994. The lignite briquette is made out of the small of the lignite, I presume—the lumps are sold or otherwise treated, are they not ?—In some cases the Bohemian lignite which comes down the Elbe is used in lump form—they burn a large amount of it there in huge lumps—but in the Cologne district they get it out in a much softer state—there are generally open diggings there, and it comes out rather like earth. That is all dried and briquetted.

16995. But not at so great a cost ?—They have not to dry it so much, I think. It contains, I think, in the worst case as it comes from the mines not more than 60 per cent. of water. 60 per cent. can be profitably dried by artificial means, and then, of course, they have not the handling of it in the way of spreading it out on the fields.

16996. (*Sir William Lewis.*) Have you had any experience of the use of peat briquettes for manufacturing purposes ?—No, except that we have burnt them for boilers with very great satisfaction in a small way for driving our own plant.

16997. You have never tried them for steam making or any such uses as coal is being applied to in this country ?—No.

16998. So that you could not give us the relative calorific value of peat briquettes for such purposes as against coal ?—No, I do not think so.

16999. (*Chairman.*) Does a peat bog grow ?—Yes.

17000. I mean does it grow in the sense of there being continuous growth ?—I believe in many cases it does. There is a regular growth taking place. *Mr. W. MacNab, F.I.C.* 20 Oct. 1903.

17001. Therefore it is increasing in quantity and in thickness, is it not ?—Yes, in some cases.

17002. Where is its life ? Is its source of life from the surface ?—I do not know that I can quite correctly answer that question, but as I have understood it is a species of plant, the sphagnum, and that regularly grows.

17003. Will it re-produce itself after you have cleared out one bog, for example ?—I think if you left sufficient suitable conditions it might. There is one aspect of the peat question which I might mention, which has been regarded as of very great importance in Germany. I saw an instance of this specially near Hanover, at a little place called Triangel—they have reclaimed an immense amount of land, they have taken away the peat and made it into all sorts of fuel and moss litter, and down below they have got into good ground which they have utilised for agricultural purposes.

17004. What is the condition of the strata there—is it clay ?—It is a mixture, and it is fairly good agriculture soil. They look upon that in Germany as a very important matter, that while they are utilising the peat they are also reclaiming the land for agricultural purposes. That would be the case here also.

17005. (*Sir George Armytage.*) They are cultivating the land underneath ?—Yes.

17006. Has that land got the growth of peat in it ? If they ceased to cultivate it, would it become a bog again ?—I hardly think so, because it has been pretty well drained for the purpose of getting at the soil below. That is, of course, only applicable where you have what I think they call here a dry moor.

17007. (*Chairman.*) It is not so easy to drain in some districts where it is flat, is it ?—In many cases the peat is almost submerged in water and extends underneath the water to a depth of often 15 or 20 ft.; for instance, at Peter's place, near Stettin, his bog is almost submerged in water, and barges float along down the canal and bring away the peat which is cut underneath the water. Of course that cannot be drained—it is so low.

17008. (*Professor Hull.*) You have opened up a very interesting question, and I should like to put two or three questions to you with regard to the formation of peat in Ireland. Have you not observed in some parts of Ireland that the peat has commenced to grow, and is growing out into what is a margin of a lake really ?—I have not seen that personally.

17009. At any rate, that is the case to such a degree that it is quite clear that many of the Irish peat bogs occupy the position of former lakes or ponds ?—Yes, they have encroached.

17010. Yes, they have been gradually encroaching upon the vegetation, and plants have been gradually growing out and taking the place of former waters. In corroboration of that, is it not the case that very often there is what is known as a peat marl of white calcareous clay at the bottom of the peat bog ?—Yes, I have seen that in Ireland and in several other places underneath the peat.

17011. That, of course, was formed under water by fresh-water shells accumulating and forming this calcareous marl. Then very often the plants in that damp and humid climate go on increasing outwards, and ultimately succeed in completely supplanting the water and converting it into a peat bog ?—Yes.

Mr. George Edward Stringer, called; and Examined.

17012. (*Chairman.*) Are you a member of the firm of Stringer & Jaggar, Limited, Park Mill and Emley Moor Collieries, Clayton West, in the county of York ?—I am.

17013. Will your evidence apply mainly to thin seams ?—Entirely.

17014. Do you speak of one particular machine, or coal-cutting machines generally ?—Generally, so far as my experience of them goes.

17015. You are connected with collieries, therefore you speak as a user of the machine, not as a maker ?—As using them in our own collieries. *Mr. George Edward Stringer.* 20 Oct. 1903.

17016. When did you begin to use the machines ?—About 1886.

17017. Have you used them continuously since 1886 ?—With the exception, perhaps, of one year.

17018. Has the use of them been not only continuous,

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Mr. George Edward Stringer.

20 Oct. 1903.

but constantly increasing?—We have increased the use of them a good deal of late years.

17019. Tell us the total output for a year; perhaps it would be better to take 1902?—In 1902 we produced 195,729 tons by machine, and during the same period, 117,490 tons by hand.

17020. Another way of saying that would be that out of about 320,000 tons nearly 200,000 tons were got by machine?—Yes.

17021. Will you please give us some idea of how that percentage of machine-got coal compared with hand-got coal has developed; how far back do the proportions we are now speaking of apply?—I think it was in 1892 that we began to extend them. We might safely go back five or six years.

17022. What is the average daily output at the present time?—About 980 tons by machine and 330 by hand.

17023. Out of 1,300 tons daily you get 980 by machine?—That is so.

17024. Is the method of working the machine what is known as the Longwall?—Almost entirely, Longwall Pack Gate.

17025. Do you use more than one kind of machine?—We use machines known as the "Diamond" coal-cutting machine, and the "Gillott & Copley" cutting machine.

17026. Are these machines, as regards their action, both rotary?—Both rotary disc machines.

17027. What do the machines weigh?—The "Gillott" is the lighter machine, and weighs about 15 cwt. The "Diamond" machine weighs from 30 to 35 cwt., but I am not sure of the actual weight.

17028. Are heading machines also used?—Yes; we use two types of heading machines. One is known as the "Ingersoll" machine, and the other as the "Champion" machine.

17029. Are the outputs of the machines about the same?—The output of the heading machines is very much smaller indeed. We only use them in narrow special work.

17030. Do they get about the same quantity per machine per day?—No, we get more by the "Diamond" machine because we have a deeper cut.

17031. Is that due to the fact that it is a heavier machine, or that in order to get a deeper cut you have to have a heavier machine?—The latter.

17032. Do the machines vary in the depth to which they will undercut?—Yes, we cut 3 ft. 6 in. with the "Gillott," and 5 ft. 6 in. usually with the "Diamond."

17033. And in height?—The height of cut varies from 4 in. to 6 in. We take out a little more with the "Diamond" than with the "Gillott."

17034. Does that mean more small coal?—No. We do not hole in the coal at all, we hole in the dirt below.

17035. Are they worked backwards and forwards along the face?—Yes.

17036. (*Mr. Briggs.*) Does that apply both to the "Diamond" and the "Gillott"?—Yes.

17037. (*Chairman.*) Does that avoid any cost of moving or "flitting"?—We have not to pay for the "flitting," and we find it cheaper not to do that.

17038. With regard to the question of the number of machines, or the question of construction, I take it, if they work only one way, you would have to take the machine back again, would you not?—Yes, we should.

17039. What length of face per shift of eight hours do you cut?—They vary from 50 to 75 yds., according to the machine used.

17040. Does that mean that one is more effective than the other, or what is the difference between the 50 and the 75?—The 75 yds. is done by the machine driven by electricity.

17041. Is that a higher speed?—We can get a greater yardage per shift from it. We can run at a higher speed.

17042. What is the number of men employed working each of the machines?—In the case of the "Diamond" machine, four; and in the case of the "Gillott," three—one less. The "Diamond" requires more men because of the deeper cut.

17043. You get more output with the "Diamond" machine. How does the four to three compare as regards output?—In the case of the three we undercut to a depth of 3 ft. 6 in.; in the case of the four we undercut to a depth of 5 ft. 6 in.

17044. Will the output per man vary in those proportions, or does the increased quantity got by the use of the four men with the "Diamond" machine make the output per man as much with the "Diamond" machine as with the "Gillott" machine?—I think quite.

17045. These men drive the machines, lay the rails, set spraggs, and remove holing dirt?—That is so.

17046. And the coal is then ready for the filler?—Quite so.

17047. What machines are used for driving your headings?—The "Ingersoll" and the "Champion."

17048. Are they percussive machines?—They are percussive machines driven by compressed air.

17049. Is there any application of electric power to those?—Not to those. I have a model here of the "Champion" machine which I thought might be of interest.

(*The Witness produced a model and explained the working of the machine.*)

17050. What do you say about the type of machines?—It is difficult for me to say which type of machine I prefer, as everything depends upon the conditions under which it is to be employed. For instance, I found some time ago in working one of our seams by a machine undercutting to a depth of 3 ft. 6 in. that the coal did not fall, and that blasting had to be resorted to; but by introducing a machine capable of undercutting to a depth of 5 ft. 6 in. the coal came down so much more freely, in consequence of the longer leverage, and the weight of coal causing it to break at the back of the fall, that blasting was almost entirely dispensed with, and a much rounder and better sample of coal was the result.

17051. In that case you would prefer that machine?—In that case, quite so.

17052. But there may be difficulties in working that machine under certain conditions?—Yes, under certain conditions. Another advantage gained in this particular case was that the roof stood better, and was easier to maintain and support, the breaks in the roof being 5 ft. 6 in. apart instead of 3 ft. 6 in., and thus entirely fresh ground was occupied each cut.

17053. (*Mr. Briggs.*) Had you any difficulty in clearing away the 5 ft. 6 in. cut in the shift?—No.

17054. (*Chairman.*) Then what do you say about driving headings?—For driving headings or narrow work the "Ingersoll" and the "Champion" machines do very good work, and effect a considerable saving in cost as compared with hand labour.

(*The Witness put in a Table and explained it to the Commissioners.*)

17055. Now what does this Table tell us?—If you refer to Section 3 on the Table you will see that I give you there the cost of driving headings by the "Ingersoll" machine in one seam—the thicker seam—and I give the cost of doing the same by hand. That is labour only in both cases.

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PARK MILL AND EMLEY MOOR COLLIERIES.

Comparative Tables shewing result of Machine and Hand Work.

	WHEATLEY LIME SEAM.				*NEW HARDS SEAM.*			
Section 1.		Quantity got.	Cost.	Remarks.		Quantity got.	Cost.	Remarks.
Shewing cost of getting Coal and tramming to Pass-bye from Longwall faces. Labour only.	Machine. Hand.	Tons. Cwts. 88,082 – 52,636 –	£. s. d. 12,609 7 – 9,187 3 –	Cost per ton in favour of Machines, 7·50*d.*	Machine. Hand.	Tons. Cwts. 49,371 – 1,741 –	£. s. d. 12,155 16 8 449 11 7	Cost per ton in favour of Machines, 2·88*d.*
Section 2.		Large, Per cent.	Small, Per cent.	Remarks.		Large, Per cent.	Small, Per cent.	Remarks.
Shewing proportion of Large and Small Coal from Longwall faces when passed over Screen with 1 in. mesh.	Machine. Hand.	61·43 50·18	38·57 49·82	Percentage of Large Coal in favour of Machines, 11·25.	Machine. Hand.	75·00 46·00	25·00 54·00	Percentage of Large Coal in favour of Machines, 29·00.
Section 3.		Cost per Yard, 4 yards wide.		Remarks.		Cost per Yard, 3 yards wide.		Remarks.
Shewing cost of driving Headings. Labour only.	Machine (Ingersoll). Hand.	s. d. 6 – 8 6		Cost per yard in favour of Machines, 2*s.* 6*d.*	Machine (Champion). Hand.	s. d. 4 6 8 6		Cost per yard in favour of Machines, 4*s.* 0*d.*
Section 4.		Large, Per cent.	Small, Per cent.	Remarks.		Large, Per cent.	Small, Per cent.	Remarks.
Shewing proportion of Large and Small Coal got from Headings when passed over Screen with 1 in. mesh.	Machine. Hand.	59·00 48·00	41·00 52·00	Percentage of Large Coal in favour of Machines, 11·00.	Machine. Hand.	73·00 46·00	27·00 54·00	Percentage of Large Coal in favour of Machines. 27·00.

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Mr. George Edward Stringer.

20 Oct. 1903.

17056. What is the cost ?—In the case of machine cut, 6s. per yard, and in the case of hand cut, 8s. 6d.

17057. Is that four yards wide ?—Yes.

17058. And the 6s. and the 8s. 6d. for labour is comparing like with like ?—Quite so—all labour.

17059. (*Mr. Briggs.*) Do they include the blowing down of the coal in both cases ?—Yes.

17060. So that every species of labour, including filling into the tubs, is included ?—Yes.

17061. (*Chairman.*) That has reference to the Wheatley Lime Seam ?—That is so.

17062. Then you have another seam, the "New Hards Seam" ?—Yes, we use the "Champion" heading machine there.

17063. What is the cost there ?—4s. 6d., 9 ft. wide.

17064. Why is there a difference ? Is it because one machine will do 3 yds. and the other 4 yds., or because you work differently ?—I am speaking of per lineal yard. The cost works out practically the same in both cases.

17065. Do you not give in the case of the New Hards Seam the cost with the machine at 4s. 6d., and the cost by hand at 8s. 6d. ?—Yes.

17066. That is 4s. difference ?—That is so, but it is a much thinner and harder seam.

17067. (*Mr. Briggs.*) The saving by machine is more pronounced by the fact of the work being more difficult by hand ?—Quite so.

17068. (*Sir William Lewis.*) That is only labour ?—Labour only.

17069. No interest on capital, or cost of repairs ?—Nothing.

17070. (*Chairman.*) Then with regard to the quantity got ?—I have not the quantity got by the heading machines.

17071. In the Wheatley Lime Seam is the proportion of large and small coal got from the heading when passed over a screen of 1 in. mesh, by machine, 59 per cent. of large and 41 per cent. of small; and by hand, 48 per cent. of large and 52 per cent. of small ?—Yes.

17072. In the New Hards Seam the proportions are: by machine, 73 per cent. of large and 27 per cent. of small; and by hand, 46 per cent. of large and 54 per cent. of small ?—Yes.

17073. From that it would appear, then, that the harder coal makes even less large coal by hand than the softer coal ?—Yes; it is a thinner seam to begin with—1 ft. 10 in. instead of 2 ft. 10 in. By hand we had to hole in the coal, and the consequence was it was cut up into small.

17074. (*Sir William Lewis.*) Do you hole the coal in each case, by hand and the machine ?—By the machine we hole in the hard ground below the coal.

17075. That accounts for the large difference ?—Quite so. I have samples of the holing with me if you care to see them.

(*The Witness produced the samples.*)

17076. (*Chairman.*) Now will you go on and tell us about these two machines ?—They are both light and handy, each weighing about 500 lbs., and are easily removed about the mine, and take little power to drive them. Two men are required to work them. They hole in the Seatstone below the coal to depths varying from 4 ft. to 6 ft. The average amount of work done by each machine is about 108 superficial feet per shift of eight hours.

17077. Is that a boring ?—Holing we call it.

17078. (*Mr. Briggs.*) Area cut away ?—Yes. The "Champion" is, I think, the more easily learnt and handled, and where both floor and roof are hard, and the seam less than 2 ft. 9 in. in thickness, I should certainly use the "Champion" in preference to the "Ingersoll," chiefly because the "Champion" is easier to fix on a hard floor, and the man driving the "Ingersoll" requires more head room. For that I refer you to figures 4 and 5 on the section I have put in. The amount of work done by each machine, the conditions being favourable, is about the same. There are no complicated parts about either machine, and nothing particularly liable to get out of order; but perhaps I ought to add that I have only used the "Champion" machine for about eight months, and during that time no repairs of any kind have been necessary. The "Ingersoll" has been used about six years.

Supplement Plates 27 and 28.

17079. (*Chairman.*) Do you anticipate from what you see after the use of eight months that the cost of repairs will be greater in the "Champion" than in the other ?—I see no reason to think so.

17080. Are the working parts more delicate ?—I do not think I can say there is any difference.

17081. Do they take about the same power so far as you know ?—Yes, so far as I know. I have never actually tested. The two motive powers I use for driving the "Diamond" and "Gillott" machines are compressed air and electricity (continuous current). The former I find very simple, but wasteful and costly. The latter we first used for driving coal-cutting machines about two years ago and it has proved very satisfactory. There is not nearly the same amount of loss of power in conveying the electric current to the machines by cables as in the case of compressed air by means of pipes, besides which it is much less costly to produce.

17082. You are now referring to the disc machines, are you not ?—Yes. In order to satisfy myself that this was the case I recently had some experiments made in order to ascertain the consumption of fuel in each case. As a result I found that the consumption of fuel per superficial foot of coal holed by the electric machine was ·81 lbs., whereas the compressed air machine required 5·76 lbs. per superficial foot holed. As, however, the machine driving the dynamo is a modern one and compounded, and the air compressors are simply high pressure non-condensing engines, the comparison can scarcely be called a fair one. Still it is, I think, quite sufficient to prove that in the consumption of fuel, at any rate, there is a considerable saving in the use of electricity as compared with compressed air for coal-cutting wherever it can be used with safety.

17083. (*Mr. Briggs.*) I suppose your mines are very free indeed from gas ?—Yes; we have no gas and no dust.

17084. Do you work with open lights ?—Yes, in the machine faces.

17085. (*Chairman.*) In speaking of "safety" you use the word in that sense ?—Quite so.

17086. (*Sir William Lewis.*) What pressure is the compressed air you are comparing with this electricity ?—Fifty to fifty-five lbs.

The inclination of the seams we work is about 3 degrees. The depth from the surface varies from 120 to 400 ft. The Wheatley Lime Seam is about 2 ft. 10 in. in thickness, and in this seam both "Diamond" electric and compressed air machines holing in the Spavin or Seatstone immediately beneath the coal are used, and also "Ingersoll" headers. This seam is also worked by hand, the holing being done by the miner in the coal, the Spavin being too hard for the pick.

17087. (*Mr. Bell.*) You have not given us the comparative cost ?—It is in the Table.

17088. (*Chairman.*) It is the comparative cost in aggregate. Are these figures in the Table tons ?—They are tons.

17089. (*Mr. Sopwith.*) Does that include interest on capital ?—No, that shows the cost of getting the coal.

17090. (*Chairman.*) Labour only ?—Yes.

17091. (*Sir William Lewis.*) It is quite possible that that 2d. might be absorbed.—Yes.

17092. (*Mr. Briggs.*) So far as cost is concerned it would be absorbed ?—Yes.

17093. The power and the interest would more than absorb 2d. ?—I think just about.

17094. (*Chairman.*) Would the out-put per man be greater with the machine ?—Yes, that is one of the advantages that we consider we get.

The New Hards Seam varies from 1 ft. 6 in. to 1 ft. 10 in. in thickness. It is worked almost entirely by machines, the "Gillott" and the "Diamond" compressed air machines being used, holing in the Spavin beneath the coal to a depth of 3 ft. 6 in., and 4 ft. 6 in. respectively; and for driving headings or

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narrow work the "Champion" machine only is used. Upon that I refer to Figs. 3, 4, and 7.

Supplement Plate 27.

As regards the comparative quantity obtained from a given area in my experience there is very little difference in this respect, whether the coal is worked by hand or by machine.

As regards output per man, in both seams I find it to be considerably increased by the use of the machines owing to the most severe part of the collier's labour being performed by them—that is to say, the holing or undercutting—and thus the collier can give more time to actually filling the coal.

17095. (*Chairman.*) That again appears on the Table ?—Yes.

Supplement Plate 27.

The strata above the Wheatley Lime Seam are shown on the section.

(*The Witness explained this to the Commissioners by means of the section.*)

The Spavin in which the machine cuts is of a rather hard nature, 8 inches in thickness, without pyrites or ironstone balls, but it is not workable by the miner with a pick. The strata above the New Hards Seam are also shown in the section. The Spavin in which the machine cuts is 8 inches in thickness, of a strong nature, and immediately below this Spavin is 2 inches of inferior coal largely intermixed with pyrites. This latter is removed by the cleaner-out and thrown into the goaf along with the holing dirt. Immediately above the coal there is a thin, irregular band of iron-stone, known locally as "dross," and the parting between the roof and the coal is very badly defined.

17096. Is that got for the purpose of iron-making ?—No, it is thrown away; it is worthless.

Comparing the coal cut by machines with that cut by hand, as regards percentage of small, I find the proportion of large coal to be distinctly greater in both seams when the machines are used—more particularly, however, in the thinner New Hards Seam, which is a very hard coal of good quality and suitable for household purposes; whereas the Wheatley Lime Seam is of a softer nature, and used chiefly for manufacturing purposes and for gas-making. As regards cost, I find a saving by the use of machines in both cases, but it is much greater in the narrow work or headings than in the longwall faces.

In addition to those named, I have found the following advantages by using coal-cutting machines: namely, (1) greater safety for the men, in consequence of the roof breaks not being so frequent, and because in hand-worked longwall faces each collier has his own particular working face; should he be absent from work, owing to sickness or other causes, his place will get behind and cause the weight to settle there, thus in many cases, causing the coal to be crushed too small, and rendering the work, not only in his own but in the adjoining places, more dangerous. Also the timbering being more systematic, it is not so liable to be left in the goaf, and thus a frequent cause of danger is largely eliminated.

17097. On that point of the machine being worked by a man to-day, who is sick to-morrow, would it be worked by someone else ?—Yes.

17098. Therefore, that again is another advantage ?—Yes.

17099. Does that happen in the case of a man absent from sickness in a seam worked by hand ? Does someone else take his place ?—It is often very difficult to get the work done.

Then (2) there is less damage to overlying seams and surface property by reason of the face being moved along much more quickly than could possibly be the case by hand labour only, thus causing more even subsidence.

(*The Witness handed in plan of working in No. 3 Pit and explained to the Commissioners.*)

You will see by that that during the year ending June last the electric machine faces were extended an average of 635 feet, whereas in the same period the hand-worked faces were extended 240 feet. (3) The working faces are also more easily ventilated, because there is always a straight wind-road along the face, and falls are of less frequent occurrence. (4) The workings are also more easily superintended, because there is a larger out-put from a similar area; and (5) there is a more regular output.

The chief difficulty I experienced when first introducing coal-cutting machines arose more from the men than the machines; not that the former were particularly unreasonable, but that the system was entirely new to them, and it required time to learn to drive the machines and become accustomed to the new method of working. I think the chief disadvantage I have experienced is the capital expenditure required to instal the machines, the cost of renewals and repairs and the cost of maintenance.

17100. Is there any objection to your telling us the cost of these machines per machine ?—I have not the particulars with me, but I know the electric machines cost us £390 each.

17101. Does that include the motor to drive it ? Everything complete.

17102. (*Mr. Briggs.*) Without cables ?—Without cables. We have the cables from the surface.

17103. That includes the machine with the motors ?—The machine with the motors to drive it. There are two motors on the machine. It is self-moving.

17104. (*Sir George Armytage.*) That does not include the dynamo at the top ?—No.

17105. (*Chairman.*) What does the other machine cost ?—The "Champion" machine costs £100, and the "Ingersoll" £75.

17106. Is the "Champion" driven by electricity ?—No, compressed air. The compressed air "Diamond" machine is nearly £100 cheaper than the "Diamond" electric machine, but I am sorry to say I do not remember the particular prices.

17107. It does not do as much work ?—We do not get as much work out of it, but it is a question of air-pressure, I think, really more than anything else.

17108. (*Dr. Le Neve Foster.*) Does the £100 for the "Champion" include the machine as we see it there, everything complete ?—Yes. I have photographs of the machines if you care to see them.

(*The Witness handed in photographs.*)

17109. (*Chairman.*) You were speaking of capital expenditure. You think the chief disadvantage is capital expenditure ?—Another disadvantage may arise from the fact that if great care is not exercised in cleaning away the holing dirt a larger proportion of small dirt will be sent out with the coal than would be the case with hand-worked coal.

17110. Is that because you hole in the coal in the one case and outside it in the other ?—Partly so, and partly because in a machine face as we work it no one man has a particular place; he has to work along here to-day and there to-morrow; consequently they do not keep the places as clean as if a man was responsible for his own face.

17111. That is only a matter of supervision ?—Quite so.

Finally with regard to the general conclusions I have arrived at as to the use of coal-cutting machines, I have no doubt that as their advantages in the thinner seams of the country become more widely appreciated, and the thicker ones gradually become exhausted, it will be found that in many cases seams of good quality down to 1ft. 4in. in thickness, or even less, can be worked advantageously.

17112. That is a very important general pronouncement. You have not said anything about whether the machine for its effective use requires a floor of certain inclination. Have you any experience or any knowledge as to whether these machines would work effectively on floors with an extreme inclination, such as we have had evidence of; say, 12 inches per yard ?—I have had no experience of that, but I do not see why they should not work up to a moderate inclination, at any rate.

17113. You can set them to the angle ?—Yes; it would not affect the machine, except that it would take more power to drag it up-hill.

17114. (*Mr. Briggs.*) It would be rather hard to keep the machine and road up to the face ?—You would have to set props to keep them up to the face.

17115. And the machine constantly moving would mean a great deal more trouble and labour ?—Yes, it

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Mr. George Edward Stringer.

20 Oct. 1903.

would mean more labour; personally, I should not care to work it, but it could be done.

17116. Have there been any disappointments in the working of the machines?—There have been many disappointments where machines have been introduced, but I venture to think that in many cases they have arisen from the fact that the type of machine most suitable for the conditions under which it is to be worked has not been employed, the conditions of the working and the material which has to be cut varying so much that a machine specially suitable for one particular class of work may be totally unfitted for another.

17117. Would that divide itself rather into collieries than into seams?—No, I should say seams and districts.

17118. Therefore your choice of the type of machine, if I understand your view correctly, is that a machine suitable for one district may not be suitable for another district; but a machine suitable to one district would be probably suitable to most of the seams of the same thickness in that district?—I think everything, almost, depends upon the nature of the seam itself and what is immediately above and immediately below it.

17119. In the first place, as regards a particular machine to which a seam is applicable, are there conditions within your experience under which the working of that seam with that machine would be inapplicable?—No, I can hardly say that except in the case of faults.

17120. Let us carry it a bit further. As regards a number of seams, let us say in your district, do the conditions vary so much between one seam and another, that one machine which is applicable to one seam would not be applicable to another seam of about the same thickness?—So far as our own immediate district is concerned, I do not think that is the case.

17121. That makes it easier. Therefore, what you say as to the choice of a machine in different districts, amounts to this: a machine of one type is better for one class of work than another, and for the different conditions under which different classes of work have to be done?—That is so.

17122. You think it rather a question of exercising as much common-sense as possible in the selection of the machine for the work?—I think that has a deal to do with it.

17123. And the disposition of those concerned to make the machine work?—Quite so.

17124. (*Sir George Armytage.*) You have to be more particular as to the material to be cut than any other condition?—Yes, I think so.

Having had no experience of the working of chain or bar machines, I can offer no opinion on their respective merits or defects, but whatever kind of machine I thought of adopting I should certainly require one that would cut either backwards or forwards, and to varying depths with little alteration, the height of the cut being sufficient to allow of a complete vertical fracture between the floor and the coal, so that if the former lifts, or the latter subsides, there is still sufficient clearance to prevent the coal being wedged fast. If the holing material was hard I should require a heavy machine with the cutter wheel or bar as near the centre of the machine as possible, so as to get a good balance, as unless these conditions are observed, the machines are much more difficult to work, especially in keeping the cutter wheel in its proper position. The success of coal-cutting machines does not, I think, altogether depend upon the number of yards cut on certain days, but on producing a constant and regular out-put, and this can only be brought about by everything being done systematically. The gates should be put in at suitable distances, so that the coal near the ends of the faces can be cleared away quickly and the machines kept running. The cross gates should be put in so as to cut off the bank gates when they begin to get out of repair, and good haulage roads should be kept as near the faces as possible.

17125. (*Mr. J. S. Dixon.*) What distance do you keep the roads apart?—16 yards at the ends of the faces, and 22 yards in the middle is the rule we have adopted.

17126. You draw the coals along the face?—Yes, between the gates.

17127. You take the tub in?—Yes.

17128. (*Sir George Armytage.*) You have no difficulty in working by electricity as regards firing the mine, or anything of that sort?—We have had no accident of any kind.

17129. Then you are very free from trouble of that sort?—Yes: the only trouble we have had with electricity has been in what we call the face cable. We had a concentric cable when first we began to use the coal cutters, and this was armoured with outside wire, and in course of time it got damaged, and we found the cable became live. We have discarded that, and covered the cables with leather, and up to now we have had no trouble of any kind.

17130. I understand you would much rather have electrical working than compressed air?—We prefer it very much: we find it much better.

17131. (*Dr. Le Neve Foster.*) What thickness of leather do you use in armouring your cables?—Not very thick. I do not really know what the thickness was: it was done by a saddler.

17132. In a continuous strip, I suppose?—Yes.

17133. You say you have had greater freedom from accidents when using machines. Do you mean accidents from falls of roof?—Yes.

17134. Can you state the proportion? Have you the figures?—No. Happily we have had very few accidents from that cause either by hand or by machine. We have been very fortunate in that respect.

17135. But still you have had less with the working by machine than by hand?—Yes, undoubtedly.

17136. Then probably you would have fewer accidents from blasting, as you blast less?—Yes.

17137. I mean to say the use of the machine would prevent, or lessen the number of accidents from blasting?—Quite so.

17138. I do not quite understand why you get a greater yardage with an electrically driven machine than with a compressed air one?—The difference arises, I think, almost entirely from the fact that we cannot keep up the air pressure to drive the engines.

17139. (*Chairman.*) It is a mere question of power, is it not?—It is a mere question of power. We have to convey the power so far in pipes, and there is such a tremendous loss unless you have tremendous pipes, that we find we have a very much greater loss by using compressed air than by using electricity.

17140. (*Dr. Le Neve Foster.*) Then you are compressing at the surface, and sending it all the way down?—Yes.

17141. You have not tried the plan of conveying your power electrically to a compressor underground not very far from the place where you are using it?—No, we have not.

17142. How would the experiments be made to determine the difference in consumption of coal when working electrically and working with compressed air?—At one of our pits we had two Lancashire boilers of exactly the same size, 30ft. by 8ft, and for the purpose of the experiments we connected one boiler to the compressing plant and the other to the electric plant; then two electric machines were run, one for 5 or 5½ hours, and the other for four hours together; the result was carefully measured, and the fuel used during that period was carefully weighed. At the same time we had a compressed air machine running, which was driven from the other boiler, nothing else taking air from the mains, but this one machine. Then the area cut at the end of five hours, I think it was, was carefully measured, and the quantity of fuel used in the time was also weighed.

17143. You found that was 7 to 1?—Yes, we found that difference.

17144. With the same amount of work?—Yes, for one superficial foot of holing.

17145. Is the object of the headings that you are driving with that machine to get freedom for the disc machine to start?—Yes.

17146. That was the object of these "stables" or headings?—Yes, of the "stables."

17147. (*Mr. J. S. Dixon.*) You mention in your evidence saving the cost of flitting the machines?—Yes.

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17148. Have you not found that it is advantageous to flit the machine from one side to another of the long wall faces, to keep it always going in the same direction? —No, we found the opposite. We have a thin seam, and we have not very much room, and it means taking the machine to pieces, and to move the 6ft. wheel and the bracket and the machine, which weighs nearly two tons, we found a very costly process.

17149. Supposing in a day shift you cannot clear away the coal from the 5 ft. 6 in. cut, how do you proceed then?—The machine simply has to stay where it is until the coal is cleared.

17150. Supposing you have cut 70 or 80 yards during the night shift, and the coal is not all cleared away during the succeeding day shift, how do you deal with it?—We should send men in the afternoon to the particular spot where the coal was left in order to get that away, so that the machine could start back. We do that regularly.

17151. (*Chairman.*) Does the wheel revolve in the same direction whether going backwards or forwards, or have you the power of reversing it?—The engine itself is reversed.

17152. (*Mr. J. S. Dixon.*) My point is this; it has been found to be an advantage to flit the machine because it can be put behind, and you can cut where the men have filled the coal during the day shift, whereas there may be coal lying in the face that is not cleared away?—We have very little trouble of that kind.

17153. (*Mr. Briggs.*) You have another shift of men whose business it is to be sent to one or the other place, wherever that happens?—Yes. I found that on one occasion we cut 215 yards by one of these electrical machines in 18 hours, including change of shifts and meal times. The coal was filled out in eight hours and the machine cut down the same face again in 16 hours, including all stoppages.

17154. (*Mr. J. S. Dixon.*) Supposing there was a breakdown in the haulage or perhaps a want of wagons on the surface, or something of that kind, the coal could not have been cleared away?—No, but this was simply one case I mentioned. We are always liable to accidents.

17155. In regard to the "Champion" machine, have you driven headings for profit, that is to say to work the coal to a profit with this machine. I do not mean to say for opening out purposes, but supposing you had a large colliery with a pillar and stall working, would you consider that you could adopt that machine to work the coal for profit—not for opening out, but for doing all the holing?—I understand what you mean, but it is rather a difficult question for me to answer, because I have never looked at it from that point of view.

17156. This is a heading machine for opening out purposes?—That is rather my view of it.

17157. It is like the "Stanley" machines. Has this machine ever been driven by electricity?—I am not aware that it has.

17158. It is by percussion?—Yes, I do not know the history of the machine; I simply know that it was brought to us, and we saw it working, and we thought it would answer our purpose, and we bought it.

17159. Do you know whether it has been adapted to work by electricity?—I do not know whether it has or has not.

17160. (*Sir George Armytage.*) Is there a machine for that purpose worked by electricity?—I think there are such machines. I have never seen one.

17161. (*Mr. Briggs.*) I see you are still working a considerable quantity of coal by hand?—Yes.

17162. Is that considered to be coal which is not suitable to be worked by machine?—Partly so.

17163. If you had a new place opened out, I presume from your experience you would work wholly by machine?—In either of the two seams we are working now, certainly.

17164. Do the men who attend to the machine set any props?—No, they do not set props.

17165. And they do not fill the coal or do the timbering?—No.

17166. And you send your men to do the timbering apart from the men in charge of the machine?—Yes.

17167. You say you think the machine could be worked advantageously down to 1 ft. 4 in. Have you considered the question from the point of view that we are dealing with in this Commission—I mean, we are taking the seams down to 1 ft. in thickness? Has your experience with the machine led you to believe that we could go any lower than that, or that 1 ft. is about the extreme limit at which we need take coal into account?—I think it is entirely a question of the selling price of coal when it is produced.

17168. We agree with that?—I think 12 in. is quite thin enough.

17169. (*Sir William Lewis.*) It is also the question of the cost of producing it.

17170. (*Mr. Briggs.*) If we could postulate that the price of coal would be £2 per ton, of course you might go below 1 ft. thick, and so on?—Quite so.

17171. But assuming that the price of coal must be kept at something like the present level in order to compete with coal from foreign countries, you think that 1 ft. is quite thin enough to take into consideration?—Yes.

17172. Notwithstanding all the advantages obtained by coal cutting machinery?—Yes.

17173. You think that is the extreme limit, and you do not think it would be profitable to work it thinner?—No.

17174. (*Mr. Young.*) You said that there were fewer accidents in getting coal by machine coal-cutting than by hand labour. Is that opinion based upon the number of men employed, or upon the quantity of tons produced, or what?—It is really our own experience. We find that by our system of working by machine, we have fewer falls of roof and fewer things happen the result of which tends to accidents than by the system under which we used to work when we worked entirely by hand.

17175. With regard to coal that is got by the coal cutter, where you hole in 5 ft. 6 in., does it come down all in a piece?—Sometimes—it varies.

17176. Is it necessary for men then to shoot it—to blast it?—Not after it is down.

17177. That is never done?—Not after it is down—we wedge it in that case.

17178. (*Mr. Briggs.*) But is it necessary to put shots in after holing to bring it down?—Yes, it is, in cases.

17179. (*Mr. Young.*) That is not what I meant. I mean when it comes down all in a piece, very often in our county they put in shots to break it after it gets down?—Yes. We do not allow it.

17180. What is the percentage of difference when the coal is worked by coal cutter as compared with coal worked by hand—what is the difference in price between round and small?—That varies entirely according to the price of the day.

17181. Just so, but what is the relative difference, say, at the present time?—I could hardly say, really—there are so many prices.

17182. You have never worked it out to ascertain the real gain by working with coal cutters compared with hand cut coal?—The figures I have given you are arrived at in this way. From time to time, ever since we began to work by machines, we have had a test made, it may be of a small quantity, or it may be larger: if I happen to be there and I see a certain class of coal which I think looks small, I give instructions that a certain test should be made, and we always take a 1 in. mesh to find out the proportion of large and small, and the figures which I have given are based upon those tests. Our system of screening is such that it would be very difficult indeed for us to take a large quantity and deal with it in the way that I think you mean—we have so many screens of so many sizes and kinds.

17183. You have never ascertained the real gain on, say, 1,000 tons worked, or one acre of coal?—No, I have never done so.

17184. Has the cost of repairs for the "Ingersoll" machine, which you have had, I understand, for six years, been very considerable?—No, very trifling.

17185. Have you any idea what the life of the machine may be?—I know we have worked it for six years, and I see no reason why it should not work another six.

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Mr. George Edward Stringer.

20 Oct. 1903.

17186. (*Mr. J. S. Dixon.*) Is the same machine now working?—Well, I am not sure of that—I had forgotten for a moment, but I remember now that they improved the machines some two years ago, and they said they would take the old ones back in exchange for the new. But I see nothing beyond ordinary wear and tear particularly liable to repair. They wear out, of course, and require repairs from time to time, which are done in the shops.

17187. (*Mr. Sopwith.*) How do you arrive at 108 superficial feet during the eight hours by these percussive drills? Are they working continuously during eight hours?—No, a man in the case of the "Champion" machine, for instance, will cut a place 3 yds. wide, 6 ft. deep. When he has done that he removes his machine to another heading, and he will do the same again.

17188. But what is this 108 superficial feet? Supposing that "Champion" cutter was practically continuously at work without shifting, what amount would it cut?—We have cut up to 160 superficial feet in the eight hours.

17189. Do you mean at that rate?—We have actually cut that in the eight hours.

17190. Yes, but you use it in the stables, where you have only a width of 4 yds.?—Speaking generally that is so, but we have used them, and if we had occasion to do so to-morrow we should use them again for heading.

17191. The way in which I would rather put it is this: during the time that the percussive machines are at work, do they cut at a much greater rate than 108 superficial feet per eight hours?—Yes, quite so.

17192. What would you put it at? Would it not be double that?—It might be more than that.

17193. Therefore if it was used, and if you were to shift it along the face in a place where the timbering is very difficult and very complicated, and where you cannot get a longwall machine to work, you might be able to do at least as much work going along the face as you would in the stables in the eight hours?—Yes, no doubt.

17194. You would do more than 108 superficial feet in the eight hours?—Yes.

17195. And it might be considerably more?—It might be.

17196. Can you state what is the comparative amount of holing done by hand by a man?—I cannot say.

17197. I rather gather that your experience would be this, that if you have much thinner seams than what you are dealing with, it is a great question whether the use of machines is a very great advantage. Would that be so? because you make out that the saving in one case was a little over 7d. in favour of the machine, and in the other case was only 2½d.?—Quite so.

17198. In the case of the thinner seam there would be comparatively less saving, probably?—I should think so. Of course in this particular case it happens that in the thicker of the two seams we get the greater saving; but it does not follow that if the seam were twice the thickness we should get the same saving as we do in the 3 ft. seam, even.

17199. No, and you have come to the general conclusion that the saving which there is in the thin seam is really in the quality of the coal?—Yes, in the better selling price.

17200. I understand that you are rather of opinion that the "Champion" coal cutter might be used advantageously in a longwall face in cases where you could not get a longwall machine to work. I am rather speaking of the difficulty that one has which one knows of one's self, that one cannot get a longwall machine to work because the timber and the roof are so bad, but you might, with a light machine, be able to place it between the timbering, and by using a cutter of 9 ft. you might be able to get a hole all along the face, working radially?—Yes, I certainly should not like to say that it could not be done, but I have never looked at the machine from that point of view.

17201. No, the advantages are so much greater, comparatively, of course, in the case of headings but there is no reason why it should not be used in this way?—No.

17202. (*Sir William Lewis.*) Could you give the Commission any idea of what the comparison would be if you debited the machine with the interest upon the first cost, and also the cost of the power applied (whether compressed air or electricity), and also the maintenance of the machine?—Yes. I will deal first of all with the fuel: taking the test we made which I have described, and taking the fuel, which was rough slack, at 5s. 1d. a ton, the cost works out at 1·5d. per ton of coal holed.

17203. (*Sir William Lewis.*) What I desire is to test what is the relative cost of the hand labour as against the machine, including all the outlay in connection with the machine.

17204. (*Mr. Briggs.*) You mentioned the cost of fuel, but I did not quite understand that it was in pence. You said per ton of coal holed?—Yes.

17205. Then how much per ton of coal holed was the cost of fuel?—At 5s. per ton, 1½d.

17206. (*Mr. Briggs.*) That is really one of the items.

17207. (*Sir William Lewis.*) That is really one of the items, but I only wanted to know whether you were taking the whole of the items in comparing it with hand labour; because this comparison which you have handed in to the Chairman only embraces labour?—Quite so.

17208. Without taking into account any of those other items which you are bound to provide, and which may have absorbed, or rather more than absorbed, the difference in some of the seams?—I may say that we take as our basis of calculation for repairs, renewals, depreciation and everything, 1·24d. per ton exclusive of fuel.

17209. Does that include the electrical power?—It is exclusive of fuel in all cases. I say it is 1½d. for fuel and 1·24d. for maintenance.

17210. (*Sir George Armytage.*) That is plus the 1½d.?—Yes.

17211. It comes to nearly 3d.?—Yes.

17212. (*Sir William Lewis.*) Are you contemplating increasing the use of these machines and displacing manual labour gradually to a greater extent than you have?—Yes, I may say that we are now duplicating our electric plant.

17213. For the purpose of applying more machines?—Yes, chiefly.

17214. And you think there will be an advantage in a longwall face in applying machines?—Undoubtedly, there will be with us.

17215. In both the thicker and the thinner seams?—Yes, quite so.

17216. (*Mr. Young.*) With regard to your remark, Sir William, about saving manual labour, did you mean the number of labourers or simply lessening the arduous labour?—(*Sir William Lewis.*) I am talking of hewers now.

17217. (*Mr. Young.*) I understand that, and you refer to saving in the number of hewers?—(*Sir William Lewis.*) Yes.

17218. (*Mr. Young.*) Do you think that would be the effect of the application of more machines—that there would be fewer hewers employed?—We get a larger output for every man employed by machine.

17219. Yes, it amounts to 7d., I see, in one case, on machine-cut coal, and 2d. in another. That would not mean much in the output of a number of hewers, would it?

17220. (*Chairman.*) But that, I think, is not the point of the whole story; I think we are rather mixing up two things, if I may venture to say so. As I understood, the quotation of 7d. or whatever the figure is, was the difference in the cost per ton of getting coal; but that hardly touches the question, necessarily, does it, of whether that system would employ more men or not, because the men might make a great deal more money working by machine than they had made working by hand, and therefore it is rather a question, not of wages—not of the cost of labour—but of the output per man. Did you give us that figure?—I did not. I have some information here.

17221. If you give us that I think it would be useful?—Yes.

17222. (*Sir William Lewis.*) That should be per man employed?—In the case of the Wheatley Lime, the average output per man, fillers only, is 7·68 tons.

17223. (*Mr. Briggs.*) For how long?—Per man per shift. The average output per man, including fillers and

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all other labour required to get the coal and to fill in the tubs—that is machine men, men to set the timber and do everything—the average output is 4·96 tons per man.

17224. Practically 5 tons ?—Practically 5 tons, whereas the output per man by hand is 3·25 tons.

17225. (*Chairman.*) Therefore it is 3·25 tons against 5 tons ?—Yes.

17226. Therefore it means that with the machines you get the same output for two men as you would get from three men working entirely by hand ?—Yes.

17227. With two machines, the output per man is practically one-third more, is it not ?—Yes.

17228. (*Mr. Briggs.*) Machine men would make more money, would they not ?—They do make more money.

17229. So that you do not get all the savings, but some of the saving goes in the shape of better wages. Is not that so ?—That is so.

17230. Although you get more tons per man, some of the saving goes to the men as well as to you ?—Yes.

17231. (*Chairman.*) It rather followed from what you said in the earlier part of your evidence, that really the machine does the hard part of the work, and this was shown in that case where the holing was most difficult ?—Yes.

17232. (*Mr. Young.*) Might I ask whether the average of the machine men working in connection with the cutters get a higher wage than those working in the same seam by hand ?

17233. (*Chairman.*) Do you mean by "wage," rate of earning ?—(*Mr. Young.*) Wage per day.

17234. (*Chairman.*) Earning per day ?—(*Mr. Young.*) Yes, earnings per day. The men who get the highest wage are the colliers, that is to say, the men who can use the pick and get the coal by hand. When such a man becomes a filler of coal, that is after the machine, he is the man who gets the largest wage.

17235. And he gets a larger wage as a filler than he does when he is getting coal by pick ?—He earns more. It is by contract, you know.

17236. (*Sir William Lewis.*) He earns more with less arduous labour ?—Yes, quite so.

17237. (*Chairman.*) I wish to ask a question with regard to one point about the "Champion" machine which I ought to have put before, I think. As I understand, this pillar is made fast to the roof, and to the floor (*describing.*) Yes, quite so.

17238. And upon its attachment to the floor on the one hand, and to the roof on the other, depends its resisting power ?—Yes.

17239. If you have a weakish roof, for example, would the vibration of that rather tend to bring it down ?—It would tend to unfasten the machine itself, and there would be time wasted in re-fixing.

17240. Therefore really for its complete efficiency you require a hard roof and a hard floor ?—That is my opinion.

17241. You have answered a question put by Mr. Briggs with regard to seams a foot thick. That is a very important point. I gather from what you say that there is no impracticability in working seams a foot thick with the machine ?—No, I do not think there is.

17242. I presume that means that you have to have a greater opening in total than 1 ft ?—Quite so.

17243. Leave aside for the moment the question which was in your mind with regard to the point of finance as to whether it was practicable from the point of view of cost,—because, as you very properly said, that would depend upon the selling price:—would it be practicable with these disc machines to get coal from seams of less than 12 in. thick. You must have an opening of a certain height ?—You must have an opening of a certain height.

17244. Therefore it become impracticable in the sense that it adds so largely to the cost ?—Quite so.

17245. That is the only impracticability, is it ?—I think so.

17246. (*Sir William Lewis.*) You would be cutting into a much larger proportion of the seam of coal by your machine in a seam under 12 in. ?—No. I should not think it would be practicable to work a seam under 12 in. if you had to hole in the coal at all.

17247. (*Mr. Briggs.*) You would have to take out so much dead work in proportion to the amount of coal that you would get ?—Quite so. You would have to take out twice as much dirt as coal.

17248. (*Chairman.*) Would you say that there is any general rule applicable with regard to the quality of coal ? Could it be said, with regard to a great many of the thin seams, that the coal itself *qua* coal is as good as the thicker seam coal in quality ?—Yes, I think so.

17249. Therefore a thin seam does not necessarily mean inferior coal ?—Not at all.

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APPENDICES.

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APPENDIX I.

A.

LIST OF WITNESSES

WHOSE EVIDENCE IS CONTAINED IN

VOL. II. OF THE FIRST REPORT*

OF THE

ROYAL COMMISSION ON COAL SUPPLIES,

[Cd. 1725, 1903],

WITH NAME, DESCRIPTION AND SUBJECT ON WHICH THEY WERE EXAMINED.

NAME.	———	No. of Questions.	Page.
ACKERMANN, Mr. A. S. E. - -	Consulting Engineer, Associate of the City and Guilds of London Institute, Associate Member of the Institution of Civil Engineers, and a Member of the Sanitary Institute. *Evidence* on use of Coal-cutting Machinery in America.	3536—3662 4499—4707	136 and 172
ATKINSON, Mr. JOHN BOLAND -	His Majesty's Inspector of Mines (Newcastle District) - *Evidence* on Thin Seams (East of Scotland and Newcastle-on-Tyne Districts).	1029—1088	44
ATKINSON, Mr. WILLIAM NICHOLAS.	His Majesty's Inspector of Mines (Stafford District) - *Evidence* on Thin Seams. *Evidence* on Deep Mining (Staffordshire District).	2228—2272 2273—2456	93
BENNETT, Mr. JOHN RYAN - -	Director of Bedminster, Easton, Kingswood and Parkfield Collieries. *Evidence* on Deep Mining (Gloucester and Somerset)	1262—1429	54
BRAMALL, Mr. HENRY - - -	Member of the Institution of Civil Engineers, a Member of the firm of Andrew Knowles and Co. *Evidence* on Deep Mining.	239—513	11
BRAMWELL, Mr. HUGH - -	Mining Engineer and Agent for the Great Western Colliery Company. *Evidence* on Waste in Working (South Wales Coalfield).	4708—4920	179
CHILDE, Mr. HENRY SLADE - -	Mining Engineer, a Member of the firm of Messrs. Childe and Rowand, Wakefield and Westminster, a Member of the Institution of Civil Engineers, a Member of the Institute of Mechanical Engineers, a Member of the Institute of Mining Engineers and a Fellow of the Geological Society. *Evidence* on Waste in Working (Yorkshire District).	5310—5763	204
DICKINSON, Mr. JOSEPH - -	A Member of the Coal Commission of 1866–71, one of His Majesty's Inspectors of Mines from 1850 to 1892. *Evidence* upon Limit of Depth. *Evidence* as to Thin Seams.	1—183 184—238	1
DIXON, Professor HAROLD BAILY-	A Member of the Commission and Professor of Chemistry and Metallurgy at the Owen's College, Manchester. *Evidence* on Underground Temperatures.	2868—2889	114
ELLIS, Mr. THOMAS RATCLIFFE -	Solicitor and Secretary to the Mining Association of Great Britain and to the South Lancashire and Cheshire Coal Association. *Evidence* on Mining Leases.	8083—8157	308

* Vol. I. of this Report contained the Report itself, which consists of a statement of the steps taken in the prosecution of the enquiry, and Vol. III. contained plans, curves and diagrams.

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LIST OF WITNESSES—*continued.*

NAME.	———	No. of Questions.	Page.
EVENS, Mr. THOMAS - - -	Mining Engineer, Past President of the South Wales Institute of Engineers, and a Member of the Institution of Civil Engineers; formerly a Colliery Manager. *Evidence* on Waste in Working.	4324—4498	167
FORSTER, Mr. T. EMERSON - -	Mining Engineer, Managing Director of the Cowpen Coal Company and Mining Agent to Lord Hastings, Lord Carlisle, and other coal owners; Representative of the Northumberland Coal Owners' Association. *Evidence* on Waste in Working (Northumberland District).	6137—6466	229
GALLOWAY, Mr. WILLIAM - -	Consulting Mining Engineer, one of His Majesty's Inspectors of Mines from 1873 to 1879. *Evidence* on Waste in Working (South Wales Coalfield).	4099—4323	159
GARFORTH, Mr. WILLIAM EDWARD	Mining Engineer, Member of the Institution of Civil Engineers, a Fellow of the Geological Society, Past President of the Midland Institute of Mining Engineers, Inventor of the Deep Undercut Coal-cutting Machine and of a Fire-damp Detector. *Evidence* on Coal-cutting Machines.	2675—2867	109
GEMMELL, Mr. JOHN - - -	Mining Engineer, Member of the firm of Landale, Frew and Gemmell, Edinburgh and Glasgow. *Evidence* on Waste in Working (East of Scotland District).	3663—4010	145
GERRARD, Mr. JOHN - -	His Majesty's Inspector of Mines (Manchester and Ireland District). *Evidence* upon Thin Seams. *Evidence* on Deep Mining.	516—740 741—873	22
GIBB, Mr. GEORGE - - -	Manager to Messrs. James Nimmo and Co.'s Collieries. *Evidence* on Coal-Cutting Machinery in Thin Seams.	874—921	36
GRAYSTON, Mr. FREDERICK ARTHUR.	Mining Engineer and Colliery Manager. *Evidence* on Waste in working (Tamworth District).	7197—7361	283
HALL, Mr. HENRY - - -	His Majesty's Inspector of Mines (Liverpool and North Wales District). *Evidence* on Deep Mining.	924—1028	39
HAMILTON, Mr. JAMES - - -	Mining Engineer, member of the firm of McCreaths and Stevenson, Glasgow. *Evidence* on Waste in Working (West of Scotland District).	4011—4098	154
HANN, Mr. E. M. - - -	Mining Engineer and General Manager for the Powell-Duffryn Company. *Evidence* on Waste in Working (South Wales and Monmouth District).	5217—5309	199
HARRIS, Mr. WILLIAM - - -	Miners' Secretary. *Evidence* on Waste in Working (Monmouthshire).	5920—6136	223
HEWLETT, Mr. ALFRED -	Managing Director of the Wigan Coal and Iron Company. *Evidence* on comparative cost of working Thick and Thin Seams during last thirty years.	2890—2949	118
JENKINS, Mr. WILLIAM -	Mining Engineer and Manager to the Ocean Coal Company, Limited. *Evidence* on Deep Mining.	2118—2225	90
KEMP, Mr. JOHN - - -	Collier - - -

LIST OF WITNESSES—*continued.*

NAME.	———	No. of Questions.	Page.
McMURTRIE, Mr. JAMES - -	Mining Engineer, Past President of the South Wales Institute of Engineers and Fellow of the Geological Society; formerly Manager of the Newbury Collieries, Coleford. *Evidence* on Waste in Working (Radstock District of Somerset).	5106—5217	192
MARTIN, Mr. HENRY WILLIAM -	Mining Engineer and Agent at Dowlais for Messrs. Guest, Keen and Nettlefolds, Limited. *Evidence* on Deep Mining (Dowlais District).	1919—2117	80
MARTIN, Mr. ROBERT - - -	Manager of the Niddrie and Benhar Collieries, Portobello. *Evidence* on Deep Mining.	1603—1918	65
MARTIN, Mr. TOM PATTINSON -	Mining Engineer, Secretary, to and representative of the Cumberland Coal Owner's Association. *Evidence* on Waste in Working (Cumberland District).	7616—7892	293
MEACHEM, Mr. F. G. - - -	Mining Engineer, formerly manager to the Hamstead Colliery Company. *Evidence* on Waste in Working (South Staffordshire and East Worcestershire).	6884—7196	250
MITCHESON, Mr. GEORGE ARTHUR	Mining Engineer - - -

APPENDIX I.—*continued.*

B.

LIST OF APPENDICES

TO THE FIRST REPORT OF THE

ROYAL COMMISSION ON COAL SUPPLIES.

VOL. II. [Cd. 1725. 1903.]

Appendix.	Reports and Papers received from persons other than Witnesses.	Page.
I.	Translation of a Memorandum by Mr. Denoel, Mining Engineer, as to the working of Coal Mines in Belgium. Supplied by the Belgian Government.	331
II.	Report of His Majesty's Consul-General at Dusseldorf, transmitting a translation of a Report by Herr Schultz-Briesen upon the working of Coal Mines in Westphalia.	333
III.	Report by Professor Albert Heim, of Zurich, with reference to the Temperatures found in the Simplon Tunnel.	337
IV.	Memorandum from Mr. E. R. Meekison, Chief Inspector of Mines Ventilation, upon temperatures and ventilation in deep mines, supplied by the Secretary for Mines and Water Supply, Melbourne.	338
V.	Extracts from a letter received from Mr. E. D. Leavitt, Consulting Engineer to the Calmut and Hecla Mining Company, with reference to underground temperatures.	338
VI.	Extracts from a letter received from Mr. Hennen Jennings, of Messrs. Wernher, Beit and Co., with reference to Deep Mining on the Witwatersrand.	339
VII.	Memorandum supplied by the Engineers of the Consolidated Gold Fields in South Africa, Limited, with reference to underground temperatures.	339
VIII.	Report by Mr. R. Arthur Thomas, Manager of the Dolcoath Mines, Camborne upon underground temperatures.	340
IX.	Observations by Mr. Frank Brain upon the working of Thin Seams of Coal in the Forest of Dean.	341
X.	Statement of Mr. H. H. Bolton, jun., upon the working of Thin Seams of Coal in N.E. Lancashire.	342

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APPENDIX II.

Letter from the Board of Agriculture in reply to a request by the Commission for information upon the following points, which have been suggested by the evidence as to the general introduction of producer gas plant and of coke ovens, with recovery of bye-products and the consequent increase in the production of sulphate of ammonia.

1. Is the appreciation of sulphate of ammonia as a fertiliser increasing ?
2. Assuming that there was an adequate supply, and that fairly uniform prices could be maintained, would the consumption of ammonia be likely to increase to any great extent ?
3. At what price could sulphate of ammonia compete with nitrate of soda successfully ?
4. Assuming that there is a largely increased production of sulphate, and that the relative values of sulphate and nitrate are based on the nitrogen values, would it be at all likely that the price of nitrate of soda would come down so much as to force down in turn the price of the sulphate of ammonia ?

BOARD OF AGRICULTURE,
4, Whitehall Place, London, S.W.
23*rd November*, 1903.

SIR,—I am directed by the Board of Agriculture and Fisheries to advert to your letter of the 5th inst., and to state, for the information of the Royal Commission on Coal Supplies (1) that during the past ten years sulphate of ammonia has made considerable progress in popular estimation. This is shown by the fact that whereas from 1894 to 1897 the value per unit of nitrogen in nitrate of soda was generally considerably higher than in sulphate of ammonia, the reverse has usually been the case since that period, although the year 1902 formed a notable exception. In this connection I am to enclose a table showing the price per ton of sulphate of ammonia and nitrate of soda in the spring of the last ten years, and exhibiting also the value per unit of the nitrogen contained in each of these two substances.

(2) The Board are of opinion that with the spread of knowledge of the value and use of artificial manures, the consumption of sulphate of ammonia is likely to increase, provided that the relationship between its cost and the value of farm produce is not materially altered.

(3) Sulphate of ammonia (97 per cent. purity) can compete successfully with nitrate of soda (95 per cent. purity) when the ratio between the prices of the two substances is not wider than the respective percentages of nitrogen contained in these two manures, namely, 20·5 and 15·6 respectively, which is equivalent to £11 16s. 6d. per ton for sulphate of ammonia and £9 per ton for nitrate of soda.

(4) This question is too hypothetical to admit of a definite answer; but it is probable that with an increased supply of sulphate of ammonia the price would fall, and there is little doubt that under these circumstances the price of nitrate of soda would be sympathetically affected.

I am, Sir, your obedient servant,
T. H. ELLIOTT.
Secretary.

STATEMENT showing price per ton of SULPHATE OF AMMONIA and NITRATE OF SODA during the Spring of the last ten years. (*Based on figures given in the Transactions of the Highland and Agricultural Society of Scotland.*)

Spring of Year.	Price per ton of Sulphate of Ammonia.	Price per unit of Nitrogen.	Price per ton of Nitrate of Soda.	Price per unit of Nitrogen.
	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1894	11 10 -	- 11 2¾	10 5 -	- 13 1¾
1895	11 10 -	- 11 2¾	8 15 -	- 11 2½
1896	8 15 -	- 8 6½	8 5 -	- 10 7
1897	7 15 -	- 7 6½	8 5 -	- 10 7
1898	10 - -	- 9 9	7 12 6	- 9 9½
1899	10 10 -	- 10 3	7 15 -	- 10 -
1900	12 - -	- 11 8½	8 - -	10 3
1901	11 10 -	- 11 2¾	8 15 -	- 11 2½
1902	11 15 -	- 11 5½	10 - -	- 12 9¾
1903	12 12 6	- 12 3¾	9 5 -	- 11 10¼

APPENDIX III.

MEMORANDUM ON THE USE OF BLAST FURNACE GAS FOR MOTIVE POWER.

By BENNETT H. BROUGH, *Secretary of the Iron and Steel Institute.*

The waste gases from blast-furnaces have for many years been successfully applied for heating stoves for the hot blast and raising steam for the blowing-engines, pumps, and lifts. The problem of using these gases in gas-engines, and so producing power direct, has of late years engaged the attention of members of the Iron and Steel Institute, and several important memoirs have been communicated on the subject.

The first suggestion to utilise waste gases in this way was made by Mr. F. W. Lürmann, member of the Iron and Steel Institute, at a meeting of the Society of German Engineers on 1st May, 1886. In Great Britain Mr. James Riley, Vice-President of the Iron and Steel Institute, was the first to apply in a practical, though limited, way the system proposed by Mr. B. H. Thwaite of utilising the power in the gases at the Wishaw blast-furnaces of the Glasgow Iron and Steel Company in 1895. The use of blast-furnace gas for motive power first aroused general interest when Mr. A. Greiner, Managing Director of the John Cockerill Company, of Seraing, Belgium, read a paper on the subject before the Iron and Steel Institute in 1898 (*Journal*, 1898, No. I., p. 21). The results of tests of the 200 horse-power Cockerill engine he described were subsequently pubished by Mr. A. Witz (*Ibid.*, 1898, No. II., p. 130); and later on a further paper describing a 600 horse-power engine was read by Mr. Greiner (*Ibid.*, 1900, No. I., p. 109). The new system derived a great impetus by the success of the gas-engine, which was shown by the Cockerill Company at the Paris Exhibition of 1900. This engine developed 700 horse-power with blast-furnace gas, and 1,000 horse-power with illuminating gas.

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In Mr. Greiner's first paper he quoted figures showing a surplus of 2,000 horse-power per 100 tons of daily make of pig iron, which, in order not to be over-sanguine, he reduced to an estimate of 1,000 horse-power per 100 tons of pig iron. Mr. W. Whitwell, in his presidential address to the Iron and Steel Institute in 1901, stated that in his firm's plant of three furnaces at Thornaby the figures work out as follows:—Total gas per hour, 2,628,000 cubic feet. Half of this is used by the hot-blast stoves, and about 239,000 cubic feet by the boilers which supply the gantry lift, leaving 1,075,000 cubic feet for raising steam for the blowing-engines, pumps, and furnace hoist. Taking the requirements of a gas-engine at 130 cubic feet of gas per horse-power per hour, this 1,075,000 cubic feet of gas is capable of producing 8,269 horse-power. The horse-power of the blast-engines, pumps, and furnace hoist engine total 1,388, leaving a surplus of 6,881. Taking an ordinary day's make at 350 tons, this gives 1,900 horse-power per 100 tons in favour of gas-engines. This calculated result comes down very close to the figures quoted by Mr. Greiner, but, if to be on the safe side his reduced estimate of 1,000 horse power as the surplus is taken, a wonderful result is obtained when taken over such a district as Cleveland. The make per day approximates 6,100 tons, and at 1,000 horse-power per 100 tons there is a surplus of 61,000 horse-power, equal to the consumption of more than half-a-million tons of coal per year. The uses that this power might be put to are endless, driving all the machinery in the works, and supplying electric light and power for outside consumption.

Indeed, it is possible now to arrive at an estimate of the waste going on in the blast-furnaces of the Cleveland district:—Horse-power in the gases, 61,000; waste heat in the iron and slag, equal to 276,140 tons of coal, or 31,500 horse-power. Total power going to waste, 92,500 horse-power.

During the last few years considerable progress has been made in the purifying of blast-furnace gas, necessitated by the introduction of gas-driven engines. Besides the well-known older appliances, the methods commonly used in gasworks have been followed, and centrifugal apparatus, particularly that of Theisen, have come into general use. It is now definitely proved that a complete purification of the gas and the elimination of moisture from it are perfectly possible, also that the quantity of water necessary for cleansing is not at all excessive.

In a paper read at the Düsseldorf Meeting of the Iron and Steel Institute (*Journal*, 1902, No. II, p. 10), Mr. W. Brügmann expressed the opinion that in spite of the notable improvements effected in the steam engine in recent years, these will with difficulty hold their own against the engines driven by blast-furnace gas. How rapidly the latter are coming into use was shown in a striking manner on comparing the Paris Exhibition with that of Düsseldorf in 1902. At Paris the 600 horse-power blowing-engine of the Delamare-Deboutteville type built at Seraing attracted the attention of technical men of all nations as the largest and sole existing machine of the kind. The gas-engines displayed at Düsseldorf were applied as widely as steam engines and were scarcely inferior to these either in number or in size.

The pioneers among German blast-works in the use of gas-engines on a great scale were the Hoorde and Differdingen Works, though at the present time nearly all iron-works are using this source of power in smaller capacities. Hoerde has three Oechelhäuser two-throw engines, each of 600 horse-power and one Deutz four-throw engine of 1000 horse-power, all of which are used for the generation of electricity, and at Differdingen there are nine Seraing machines, each of 600 horse-power, six of which supply the blast. Double-acting two-throw engines of the Körting system have also recently been put in operation at various works. It is claimed for engines driven by blast-furnace gas that they are highly economical. It is true, when running at full load, that the gas consumption is low. But with lighter loads a corresponding diminution in the consumption of the gas does not occur, as is the case with steam-engines.

The power absorbed in washing the gas is also not inconsiderable, and reduces the net available supply of power by an appreciable amount. With regard to the initial cost of installation as compared with a good steam-power plant, the cost of a blast-furnace gas-engine with gas-washing apparatus is approximately the same as that of a steam-engine with a battery of boilers. Neither the existing technical defects nor the question of cost will, however, prevent the adoption of both blast-furnace gas-engines and of ordinary gas-engines, as is evident from the rapidly extending use of these. It may rather be assumed that the employment of such machines is still only in the initial stage. Mr. Fritz Lürmann (*Journal of the Iron and Steel Institute*, 1901, No. I) expressed his astonishment that both English and American ironmasters have been so tardy in profiting by this source of economy, and indicates in the following table how completely German ironworks have taken the lead in this respect. This gives the distribution of the total power in the various countries as follows:—

April 18, 1901. Makers.	Germany.*	Austria.	Belgium.	Italy.	France.	Russia.	England.	Luxemburg.	Spain.
	H.-P.	H.-P.	H.-P.	H.-P.	H.-P.	H.-P.	H.-P.	H.-P.	H.-P.
Seraing	3,900	—	7,600	—	—	700	600	6,000	—
Wetter	2,400	—	—	1,200	—	—	—	—	—
Mülhausen	3,000	—	—	—	—	—	—	—	600
Breitfeld Danek & Co.	600	850	—	600	—	—	—	600	—
Schneider & Co.	—	—	—	—	7,400	—	—	—	—
Total	9,900	850	7,600	1,800	7,400	700	600	6,600	600
Körting Brothers	5,105	—	—	—	—	—	—	—	—
Otto-Deutz	10,120	—	—	—	—	30	—	3,200	—
Deutsche Kraftgas Gesellschaft	12,800	2,000	—	—	—	1,500	—	—	—
Nuremberg	6,740	—	—	—	—	—	—	—	—
Total	44,665	2,850	7,600	1,800	7,400	2,230	600	9,800	600

* Including Luxemburg.

The result of Mr. Witz's experiments, to which reference has been made, showed that a Cockerill engine of large size did not use more than 100 cubic feet of average blast furnace gas per effective horse-power per hour. It was pointed out by Mr. D. Selby-Bigge in a paper read before the Iron and Steel Institute (Journal 1902, No. II. p. 243) that this amount is less than one-fourth the consumption of gas required to develop the same power from boilers and good modern condensing steam-engines; so that there is an immense surplus of power to be obtained from a blast-furnace if the blowing-engines are worked by gas, which can be still further increased if the

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gas is properly cleaned for the stoves, and its efficiency thus increased. It is estimated that for every 100 tons of coke used in an ordinary Cleveland blast-furnace, after making ample allowance for gas for the stoves and power for the lifts, pumps, etc., and for gas for working the necessary blowing-engines, there is a surplus of at least 1500 horse-power, so that by economising gas by cleaning, and developing the necessary power by gas-engines, every blast-furnace owner would have a very large surplus of power for his steel or other works, in the form of electricity or otherwise.

It would be difficult to over-rate this new development in power production. In Great Britain large sources of water power are unknown, and the sources from which electricity can be produced most economically will be undoubtedly due to the development of large power gas-engines making use of the surplus gases from the blast-furnaces, which would otherwise be wasted.

Engines have been constructed and are at work of 1200 horse-power, and an engine of this type is now building for no less than 2500 horse-power.

APPENDIX IV.

AN ANALYSIS OF THE NATURAL GAS AT HEATHFIELD, SUSSEX.

By Professor H. B. Dixon and Dr. W. A. Bone.

When the possibility of the industrial application of the Heathfield natural gas was brought before the Royal Commission on Coal Supplies one of us (Professor Dixon, a member of the Commission) was asked to visit Heathfield and examine the nature of the gas on behalf of the Commission. Accordingly, a visit was made to Heathfield on the London Brighton and South Coast Railway on 10th October, 1902, when several samples of gas were sealed up in glass tubes and brought to Owens College for analysis.

According to Mr. Richard Pearson, Managing Director of the "Natural Gas Company," the gas was first discovered in 1836 in a well which was being sunk at Hawkhurst in West Sussex. In the Sub-Wealden boring (1873–75) the gas was met with at Netherfield on the South-Eastern line to Hastings. Gas was first encountered at Heathfield in 1895 in sinking a well for water in the hotel yard about 50 yards from the station. In 1896 the same firm of well-sinkers met the gas at a depth of 300 feet in a shaft sunk for water at the station; no water was found, but the gas continued to escape, and was then used for lighting the station.

At the date of our visit six wells were either sunk or in course of sinking, and gas had been struck in all of them after the bores had penetrated through the 300 or 400 feet of surface bed of sandstone and marl, which forms, according to Mr. Pearson, the impervious lid to the natural holder of gas.

The gas was issuing from the bore-holes at a pressure of between 140 and 200 lbs. per square inch, and was being used to drive gas engines and to light (with incandescent mantles) the station and a number of houses in the village. Lighted at an inch pipe at the mouth of a bore-hole, the gas burnt with a large flame giving a fair light, a flame more luminous than that of fire-damp from coal mines. In an Argand burner the gas burnt with a moderately luminous flame, but gave little light in an ordinary bats-wing, so that it was difficult to understand how the gas could contain 5½ per cent. of ethylene as we were informed, unless indeed the free oxygen, also said to be present, was sufficient to destroy its lighting power. Our analyses, however, show that neither ethylene nor free oxygen was present in the gas we collected. To avoid the possible loss of free oxygen by partial combustion in the tube while the drawn-out ends were being sealed, a sample was collected by closing the ends with parafined rubber: it gave the same result.

The gas was transferred by means of a Töpler pump from the collecting vessels into small tubes standing over mercury. The analyses were made over mercury in a modified McLeod apparatus; and all the re-agents used were freshly prepared.

A.—*Preliminary Examination for Carbon dioxide. Oxygen, Unsaturated Hydrocarbons, and Carbon monoxide.*

(1). The absence of carbon dioxide and oxygen was proved by exposing the gas successively to the action of (*a*) strong potash solution, and (*b*) strongly alkaline pyrogallol. In neither case was there any appreciable absorption.

(2.) The absence of unsaturated hydrocarbons was shown in two separate experiments in which samples of gas were successively treated with (*a*) fuming sulphuric acid, and (*b*) strong potash solution. No change in volume occurred in either experiment.

(3.) The gas always showed an appreciable contraction—as nearly as possible 1 per cent.—when successively treated with ammoniacal cuprous chloride and dilute sulphuric acid. No precipitate of cuprous-acetylide was formed. Since the foregoing experiments exclude the possibility of this contraction being due to oxygen or unsaturated hydrocarbons, it can only be attributed to the presence of carbon monoxide.

B.—*Explosion Analyses for Saturated Hydrocarbons, plus possibly Hydrogen, after removal of Carbon monoxide.*

After removing the carbon monoxide from a considerable volume of the gas (by means of ammoniacal cuprous chloride and dilute sulphuric acid), we proceeded to determine (1) the contraction, C, obtained on exploding measured volumes of the residual gas with a large excess of oxygen and air, and (2) the absorption, A, when the products of explosion were subsequently treated with strong potash solution, (3). The following results were obtained:—

	1	2	3
Volume of Gas taken (corr.)	48·25	55·70	58·75
Volume of Oxygen and air added	457·45	468·30	465·45
C.	94·35	109·10	115·20
A.	48·25	55·90	58·80
$\frac{C}{A}$	1·956	1·952	1·959

C.—*Proof that the Gas does not contain free Hydrogen.*

Before the foregoing results could be interpreted it was necessary to ascertain whether the gas contained free hydrogen. This was done by exposing some of the CO-free gas to the action of "oxidised" palladium sponge at 100° for twenty minutes, in an apparatus similar to that described in a previous paper (Bone and Jerdan, Trans, 79, p. 1044, 1901), and afterwards redetermining the ratio $\frac{C}{A}$ when the residual saturated hydrocarbons were exploded with excess of oxygen and air. The results obtained were as follows:—

	4	5
Volume of Gas taken (corr.)	62·3	55·3
Oxygen and air added	472·5	493·0
C.	121·8	108·2
A.	62·2	55·4
$\frac{C}{A}$	1·958	1·953

A comparison of these numbers with those given in the preceding section shows clearly that the gas contained no appreciable quantity of free hydrogen. The five explosive analyses indicate, however, the presence, besides methane, of a small proportion of some higher saturated hydrocarbon, which we may reasonably suppose to be ethane. Assuming this to be the case, we may now give the percentage composition of the CO-free gas calculated from the five analyses in question:—

	1	2	3	4	5	Mean.
Methane	94·10	93·88	94·40	94·30	93·90	94·10
Ethane	2·95	3·23	2·77	2·76	3·13	2·97
Nitrogen, by difference						2·93
						100·00

The composition of the original gas was, therefore, as follows:—

Carbon Monoxide	1·00
Methane	93·16
Ethane	2·94
Nitrogen, or other inert gas, (by difference)	2·90
	100·00

Owens College, Manchester.

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APPENDIX V.

MEMORANDA ON THE MOND GAS PLANT USED BY MESSRS. CADBURY AT THEIR BOURNEVILLE WORKS.

Questions addressed by the Commission to Messrs. Cadbury on the 6th of March, 1903, and Replies received thereto.

1. What is the size of installation ?—Most of our plant has been put in for 1,000 H.P.

2. What was the cost ?—The cost was £4,442, which includes Machinery, Royalty, Buildings, and Excavations.

3. How long has the producer gas been in use ?—Eleven months, one week.

4. For what purpose is it used, *i.e.* power, heat or light ? —The power from this engine is used entirely for generating electric current by means of gas engines.

5. Is the user continuous or intermittent ?—The plant is at work about thirteen hours each day, and is not used Saturday afternoons or Sundays.

6. What is the result of the use of the producer gas from the point of view of economy ?—The producer gas has resulted in great economy, at least half the cost of fuel being saved. (We append* herewith a copy of a recent letter from us giving the latest test of our gas plant and showing the works cost of current.).

7. Is there any difficulty in getting a supply of suitable coal ?—None whatever.

8. Are there any difficulties or dangers connected with the use of the gas ?—We have none.

**Mond Gas Plant.*

We think it will interest you to know the latest experience we have had with this gas plant, driving our gas dynamos. Our plant is built for 1,000 I.H.P., but has only one 500 H.P. producer yet erected.

The gas from this plant is driving two Westinghouse gas engines, each of 220 B.H.P. The number of units generated by this plant per week is about 12,000, so it will be seen that the present load is only a light one.

The cost per kilowatt, given below, includes all the stand-by losses of about twelve hours each night, Saturday afternoons, and Sundays, and the figures, although based on the best results so far obtained, do not vary from the worst by many per cent.

Gas plant labour	.08d. per unit
Generating plant labour	.07d. „ „
Producer coal	.12d. „ „
§Steam coal (7 lbs. steam—1 lb. coal)	.01d. „ „
Oil	.06d. „ „
Total	.34d.

§ When we have your exhaust gas heated boilers fixed, this amount will, we hope, be removed altogether.

These figures are the works cost, and do not include depreciation on machinery, nor does it include supervision.

We can hardly compare the cost of running a gas plant with a steam driven one, but so far as we can judge, it saves at the very least one half the coal that would otherwise be used.

We may say we are very pleased with the operation of this plant, and with the entire absence of smoke. We hope this may lead to the gradual pulling down of our chimneys which are of such detriment to the village life which surrounds us. We shall always be pleased to show any of your friends the gas plant in operation.

REPORT ON COST OF RUNNING PRODUCER GAS ENGINES AT THE WORKS OF CADBURY BROS., LIMITED, BOURNEVILLE.

Actual cost per B. T. U. for 4th quarter 1902, and 1st, 2nd and 3rd quarters, 1903.

The number of units generated in the four quarters were respectively 97,624, 135,549, 107,012, and 124,067, a total of 464,252, deducting 28,127 units used to drive accessories and lighting of station, the net number of units supplied to the works in the year equals 436,125.

		Cost per unit.
Depreciation	1,594	=·87
Renewals, Gas Plant	55	=·05
„ Gas Engines	47	
Repairs, Gas Plant	53	=·03
„ Gas Engines	11	
Coal, including the production of steam for gas plant	319	=·17
Oil	289	=·15
Foreman's Management	=436125	
„ Gas Plant	8	=·01
„ Gas Engines	22	
Wages Gas Plant	189	=·19
„ Gas Engines	174	
Taxes	111	=·06
Office Management for both	31	=·01
Waste and rags for both	18	=·01
Oil for Gas Plant	25	=·01
Totals	2,946	1·56

The above figures include all stand by losses, which are very considerable, as the plant only runs twelve hours per day, and stands the whole of Saturday afternoon and Sunday.

Coal.—The average coal consumption, including steam for gas plant, for the year is 2·9 lbs. per Board of Trade electrical unit. Estimated at 1·5 lbs. per I.H.P.

Gas Analysis.

The following is the average of 124 samples taken during the year :—

Carbon Dioxide	12·7 per cent.
„ Monoxide	16·7 „ „
Hydrogen	21·5 „ „
Methane	2·6 „ „
Nitrogen	46·5 „ „
	100·0 „ „

Average total combustibles, 40·8 per cent.

Average heating value 143·7 B.T.U. per cubic foot (lower value).

Coal Analysis.

The following is the average of two samples of "Newdigate Beans," which is at present being used :—

Moisture	8·04 per cent.
Hydro Carbons	30·68 „ „
Fixed Carbon	57·94 „ „
Sulphur	·78 „ „
Ash	2·56 „ „
	100·00 „ „

Average heating value 13,119 B.T.U. per lb.

Details of Gas Driven Power Plant.

Gas Plant.

1. 500 H.P. 5 ton Mond Producer and superheater.
1. 1,000 H.P. Gas Cleaning and Air Heating Tower and Plant.
1. Gas Holder, 20 feet in diameter, 1,800 cubic feet capacity.
2. Scrubbers, each 7′ × 7′ × 4′8″ deep.
3. Water Circulating Pumps (one spare) each with two steam cylinders 6″ × 6″ and water cylinders 6″ × 6″, capable of delivering 2,000 gallons of water per hour.
2. Thwaites' Blowers (one spare) steam cylinder 8″ × 8″, each capable of delivering 2,000 cubic feet per minute.
1. Tar Extracting fan, 10″ outlet.
1. 10 H.P. electric motor for driving the washers and fan.

Power Plant.

2. 19 × 22 Westinghouse 3 cylinder vertical gas engines.
2. 150 K.W. generators, direct coupled to above.
2. Air Tanks for starting engines (working pressure 150 lbs.)

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Power Plant—cont.

2. Reavall's direct driven Air Compressors (5 H.P. each) for filling above.
2. Direct coupled motor-driven Centrifugal Pumps (2½ H.P. each) for circulating jacket water.
1. 14 amps motor generator, 110 volts, for electric ignition.

Similar figures for the quarter ending December, 1903.

Number of units generated, gross	223,107
,, ,, ,, ,, for use of power station	7,552
Number of units generated, for works	215,555

Actual cost per B.T.U. for 4th quarter, 1903.

	£.	s.	d.	Cost per unit.
Depreciation, Machinery 10 per cent., buildings, 7½ per cent., including new additions to capital except newplant	401	4	1	·443
Renewals, Gas Plant and Gas engines	27	1	11	·03
Repairs, Gas Plant	11	14	8	·02
,, Gas Engines	4	5	4	
Coal, allowing 10 per cent. for the production of steam for gas plant. 189½ tons at 9s. 5d.	98	3	0	·109
Oil, Gas Plant	5	16	2	·08
,, Gas Engines	68	6	8	
Foreman's Management, Gas Plant (estimate)	2	0	0	·008
Foreman's Management, Gas Engines (estimate)	5	10	0	
Wages, Gas Plant	102	0	0	·12
,, Gas Engines				
Taxes	27	15	0	·03
Office Management (estimate)	8	0	0	·008
Waste and rags	3	15	0	·004
	765	11	10	·852

Note.—Allowing for increased cost of coal per ton delivered, the coal consumption per K.W. is about the same as for previous twelve months.

APPENDIX VI.

BRIQUETTES.

Summary of replies sent by ten firms engaged in the manufacture of patent fuel, in answer to the following questions:—

1. What is your annual production?—The figures for some years should be given in order to show whether the industry is progressing or not.

The total production in 1902 of eight firms was 1,053,574 tons, ranging from 5,741 to 271,510 tons. All these firms except that with the production of 5,741 tons are in South Wales. Six of these firms also gave the figures for 1899 which amounted to 767,273 tons, as compared with 776,323 tons in 1902, three firms showing an increased, and three a decreased production. One firm, which manufactures chiefly for domestic purposes, states that the demand for briquettes depends principally on the price of House Coal. Opinions differ as to whether the industry is improving its position or not. One firm states that the exports from the United Kingdom for January and February, 1903, were only 100,000 tons, as compared with 150,000 tons in January and February, 1902.

2. What is the composition of your briquettes—the principal ingredients such as peat or coal, the quality of the coal used, the binding material, etc.?—The ingredients are in all cases coal and pitch, the proportions being practically the same in the four cases where they are specified—in three 90 per cent. coal, 10 per cent. pitch, in one 88 per cent. small good house coal, 12 per cent. pitch. The coal is in most cases described as small steam coal; anthracite and small good house coal are each mentioned once. The pitch is mostly described as coal tar pitch. One firm states that the ingredients are ground to a fine powder, are then heated by steam at a pressure of 50 lbs., and then pressed into briquettes.

3. What is the size, shape and weight of the briquettes?—The sizes vary from 5 × 2½ × 3″ to 10 × 8 × 7″, most of the blocks being 9 or 10 × 5 or 6 × 4 or 5″. The shape appears in all cases to be oblong and rectangular—corners usually rounded. The blocks range from 1 to 25½ lbs., 7 to 16 lbs. being the usual weight.

4. What are its heating qualities?—These are given in most cases as 7,500 calories, one instance is quoted in which a block recovered from a wreck after immersion for forty years showed 7,810 calories. They are also given as being in one case equal to and in another slightly less than the best Welsh steam coal, and as being better than the coal from which the fuel is made.

5. Does it create much smoke in burning?—In most cases it is said to be practically smokeless, in others to be much the same as the coal from which it is taken. In one case it gives a greyish smoke when firing is going on, but this disappears within a minute. The addition of more pitch would make more smoke.

6. For what purpose are they sold and used—domestic or steam raising?—In seven cases, which include all the large South Wales firms and a very large percentage of the total output—the briquettes are used wholly or mainly for steam raising, especially for locomotives—to a small extent for domestic purposes. In the remaining four cases they are used wholly or mainly for domestic purposes.

7. Are any of the briquettes exported? If so, what proportion of your output, for what purposes, and to what countries?—Practically the whole of the output of the same seven large South Wales firms is exported, chiefly to European countries, and especially to the Mediterranean, but also to India, Cochin China, Algeria, West Coast of Africa, Mexico, West Indies, South America, and the Pacific Coast of North America. These exported briquettes are used for steam raising, chiefly in locomotives. The four other firms who make briquettes for domestic purposes export none.

8. What is the cost of manufacture and what is the selling price?—The cost of manufacture varies with the cost of the ingredients [pitch was 50s. to 55s. a ton in April 1903; a year before it was 30s. to 35s., and the price of small coal has also risen]. It is given in two cases as 8s. 6d., and 10s. to 11s. respectively. One colliery in the Midlands gives it at labour, 9d. per ton; steam, 6d.; wear and tear, 6d.; stoves, 1d.; pitch, 6s. 8d., total 8s. 6d. per ton, which, with a selling price of 12s., leaves a margin of 3s. 6d., out of which has to come the cost of the coal. Therefore, with small coal at more than 3s. 6d., as at present, briquette making does not pay. The selling price is given as:—

(1) 13s. 6d. per ton f.o.b., exclusive of (*a*) tax; (*b*) 1s. a ton stowage; (*c*) 2d. a ton wharfage. (2) 13s. 6d. per ton including tax; (3) 13s. 6d. to 15s.; (4) 11s.; (5) 12s.

9. Any other information which appears to you likely to be of service to the Commission.

Coal Tax.—As the South Wales firms export practically all their output, the tax affects the whole instead of only a portion of their business. Large quantities of briquettes are made on the Continent (Germany, Belgium, France, Italy), and fresh factories are constantly being started in countries to which we export. Competition is therefore getting keener in those countries, and handicap of the tax is being more severely felt by the British firms. One firm states that the exports from the United Kingdom for January and February, 1903, were only 100,000 tons, as compared with 150,000 tons in January and February, 1902.

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Export Duty on Pitch.—A duty of 7s. or 8s. per ton is suggested by one firm, as a means of preventing the export of pitch, and thereby reducing its price in this country.

Extra Freight.—The extra freight of about 9d. per ton over the freight for coal (coal 2½d. per ton, patent fuel 1s. per ton), owing to the extra labour necessary for stowing patent fuel, puts the latter at a disadvantage.

Non-Deterioration.—Patent fuel does not deteriorate either (1) by being stored in tropical countries, or (2) by being kept for very long periods, thirty or forty years. It is then almost, if not quite, as efficient as when first manufactured.

Foreign Countries.—On the Continent, particularly in Germany, Austria, France, and Italy, this industry is rapidly increasing. The following extract from the United States Consular Reports, August 16th, 1902, shows the present condition of the industry in Germany:—

BRIQUETTES IN GERMANY.

U.S. Cons. Reps., Aug. 16, 1902.

The briquette manufacture is controlled by a syndicate, which includes among its members more than nine-tenths of all the producers in this country, and regulates the output and prices for each year. From the official report of the syndicate for 1901, which has recently appeared, the total output during last year was 1,566,385 tons, to which is to be added the product of makers outside the syndicate, consumed at works, small retail sales, &c., making a grand total of 1,643,416 tons.

The average selling price in large quantities was 13.33 marks (3.16 dols.) per ton, as against 12.27 marks for the year previous, so that, notwithstanding the general relaxation of industrial activity and the diminished pressure upon the coal supply, the ruling price was the highest that had been realised since 1891. Of the 1,566,385 tons sold by the syndicate last year, 749,208 tons were taken by the German railways, 124,380 tons were sold to retailers, 497,136 tons were sold to factories and works of various kinds, and 149,089 tons, or 9.8 per cent., were used by German merchant steamers and the navy or exported to the German colonies or neighbouring European countries.

The following tabulated statement shows the production, the sales of the syndicate, and the mean price per ton for the past eleven years:—

Year.	Production.	Sales of Syndicate.	Price per Ton.
	Tons.	Tons.	Marks.
1891	482,495	202,780	12·67
1895	796,363	780,185	9·07
1899	1,530,816	1,485,130	10·66
1900	1,563,928	1,519,811	12·27
1901	1,566,385	1,560,230	13·33

The syndicate produces to a large extent briquettes made from coal screenings, which require a matrix or binder of some plastic inflammable material, and for this purpose 116,956 tons of mineral pitch were used, which cost on an average about 2*l.* per ton delivered.

Another United States Consular Report (No. 1615) states that the Dortmund Syndicate possesses twenty-one coal dust briquette factories, with an annual output of 2,100,000 tons of so called "industry briquettes."

The lignite briquette manufacture is much larger—286 factories working up annually 44,211,000 tons of lignite.

According to this same report (No, 1615) "the outward cleanliness of Berlin and other German cities is principally due to the general consumption of brown coal briquettes for household and steam fuel. Being made without tar or other artificial binder, they are practically smokeless, and are clean, easy to kindle, burn clearly, and are cheaper than good bituminous coal.

Lignite to be workable by usual processes must contain at least 30 per cent. of water. . . . German lignite contains 46 to 52 per cent. of water, and can generally be cut with a spade. The crude brown coal is crushed, pulverised, run through a revolving tubular cylinder heated by exhaust steam from driving engine, down an inclined plane into the machine press that stamps it into briquettes; being, during its passage through the cylinder, exposed to a temperature sufficient to develop the latent bitumen in the lignite and to remove any excess of moisture above 45 per cent, which is the ideal proportion.

The lignite-briquette factory at Lauchhammer has eight presses and other necessary plant, all driven by electric motors, the current being generated by steam evaporated with wood from the mines. Each press weighs thirty-two metric tons and turns out seventy tons of briquettes in a double-turn day of twenty hours. The heating and drying apparatus for each press weighs eighteen tons and with the press is heated by exhaust steam from the Corliss engine, the total supply for eight machines equalling 150 horse-power. 125 horse-power is required to drive each press and dryer. This plant turns out from 500 to 600 tons of briquettes per day, which sell on cars at the factory at an average price of eight marks per metric ton of 2,204 lbs."

In the United States several attempts have been made to utilise the waste product from both the anthracite and bituminous mines, and to improve the quality of lignite, by mixing them with tar, petroleum, etc., but none of the enterprises have been successful commercially. Probably because of the low price of coal.

[A brief history and detailed information as to the various processes of the patent fuel industry may be found in "Briquettes and Patent Fuel" by P. R. Björling, published in 1903.]

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APPENDIX VII.

PEAT.

A.—Questions Addressed to, and Answers received from Mr. C. Turnor.

1. Has peat fuel ever been used for power producing, as a substitute for coal? How does peat fuel compare with coal in bulk, *i.e.*, will a pound of coal evaporate more water than a pound of peat fuel?

Ans. Yes. It has been used in Canada and on the Continent on a considerable scale; but so far only experimentally in the United Kingdom.

Peat fuel varies greatly in density; on an average its caloric value may be taken as not so good as Anthracite, but better than soft coal.

As to weight, a recent Canadian experiment gives the following figures:—

Bituminous Coal	- -	73 lbs. per cubic ft.
Peat Fuel	- - -	83 „ „ „ „
Anthracite Coal	- -	93 „ „ „ „

As to steam raising, the following is an account of another Canadian experiment:—"The coal test was commenced at 8.45 a.m., December 21, 1897, and continued until 8.45 p.m., or twelve hours. The fire was drawn at the commencement and fresh fire started with weighed coal. The height of the water in the glass was marked by a string tied around same. Indicator cards were taken simultaneously from high and low pressure cylinders every five minutes, and the ammeter was read on an average twice a minute during the test. The steam pressure was observed at every indication of the engine, and the feed water temperature was taken every fifteen minutes. At the end of the test the fires were practically allowed to burn out, the height of the water in the glass being the same as at the start, and when steam began to fall the test was considered finished. The coal was weighed to one pound.

Repairs to condenser occasioning delay.—"Another test with peat was commenced exactly as before, by drawing the fires, etc., at 2.40 p.m., and continued until precisely 9.40, or seven hours. Indicator diagrams, ammeter readings, steam pressure, and feed water temperature, were taken with great regularity, as during the coal test.

"During the peat test the steam was kept remarkably steady at 90 lbs. with the greatest of ease, and it was observed that the best results were obtained by keeping a fire from four to five inches thick and firing one side at a time, allowing considerable time to elapse before the other side was fired.

"The ash was weighed from the peat, from the total amount burned, *i.e.*, the amount burned from 11.15 to 1.25 and from 2.40 to 9.40, amounting to 91 lbs. for 3,983 lbs. peat, which is equivalent to 68 lbs. for the 2,984 lbs. burned during the seven hours of what we might term the test proper.

"The following gives in tabulated form the results of the test:—

Points Observed.	Coal.	Peat.
1. Date of test	Dec. 21, 1897.	Dec. 22, 1897.
2. Duration of test in hours	12	7
3. Average E.H.P.	42	46
4. Average I.H.P.	60·8	65
5. Total fuel burned in lbs.	4,195	2,984
6. Average steam pressure	88	90
7. Average feed water temperature, deg. Fah.	102	50
8. Hourly fuel consumption in lbs.	349·6	426·3
9. Fuel per E.H.P. hour in lbs. observed	8·32	9·267
10. Fuel per I.H.P. hour in lbs. observed	5·768	6·558
11. Total ash in lbs.	250	68
12. Percentage of ash	6	2.28
13. Relative value of fuels as per indicator diagrams (actual conditions)	100	86·3
14. Relative value of fuels per indicator diagrams, taking difference in feed water, temperature and steam pressure into account	100	90
15. Relative value of fuels as per ammeter readings, (actual conditions)	100	88·6
16. Relative value of fuels as per ammeter readings, taking difference in feed water, temperature, and steam pressure into account	100	92·3
17. Mean of Nos. 14 and 16.	100	91·15

"As the ammeter readings were taken once every thirty seconds, the comparative results would be more accurate if we based our calculations on these, instead of from diagrams; therefore items No. 15 and No. 16 are calculated in this manner, and No. 17 is the mean between the ratios calculated as per the diagrams and the ammeter readings, which we are safe in taking as absolutely correct. From this we see that the thermal value of 100 lbs. of peat is equal to 91.15 lbs. of Reynoldsville Mine Run Coal of excellent quality.

"It should be here explained that this test was made in a furnace constructed to suit the requirements of coal and not thoroughly adapted to get the best of results from peat. Had the grate bars been arranged to suit the new fuel and other requisite changes been made, it is quite possible that the slight apparent advantage in favour of coal would have been wiped out, if not even reversed."

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2. Has it been used commercially, *i.e.*, has it been possible to use peat fuel profitably in competition with coal ?

Ans. So far not on a commercial scale in this country ; no plant to my knowledge has been run profitably for even six months ; from the experiments made it would seem that to realise a profit, the cost price at point of production should be between 5s. and 8s. per ton. This could only be definitely stated after a plant had run continuously for months.

But on the Continent and in Canada, there are several instances of successful peat fuel works. (*See infra.*)

The great difficulty in the British Isles is the damp climate. Peat after being cut gives up its initial 30 per cent. of moisture more slowly here than elsewhere ; and even in a good season peat will only dry in May, June and July.

The one thing necessary to make the manufacture of peat fuel a success in Great Britain is a *Continuous Process*, i.e., one which shall take the peat directly from the bog, and without the intermediate "air drying" artificially drive out about 64 per cent. of water. It will have to do this at a cost of not more than 7s. a ton, and do it all the year round, in order to be profitable. At present there is no such process.

A recent demonstration of the use of centrifugal force and electricity in drying peat gave the following analysis :

Raw peat moisture - - - -	87.2
After 40 minutes centrifugal treatment -	85.0
After electric current for 15 minutes -	83.3
Briquette on leaving machine - - -	74.3
„ 48 hours old - - -	74.1
„ 1 week old - - - -	58.9
„ 2 weeks old - - - -	45.7

3. What are the processes which peat must undergo in order to be available as fuel, and is there any likelihood that those processes will be simplified or cheapened ?

Ans. So far the peat has to be cut from the bog (when it has over 80 per cent. of water) and air dried down to 50 per cent. water ; then broken up by a machine for that purpose ; artificially dried till the water is reduced to between 12 and 16 per cent.; and again pulverised and compressed by one of the various types of machines for that purpose. All these processes will undoubtedly become cheaper and simpler. The great difficulty is the getting rid of the percentage of water between 80 per cent. and 50 per cet.

4. Is the installation of the plant very costly, or is it comparatively a simple matter ?

Ans. In Canada there have been effective plants established for £2,000, and estimates for the various plants range from that to £30,000. (*See infra.*)

5. Is any mixture of any other substance, *e.g.*, coal dust or tar, necessary in the manufacture of peat fuel ?

Ans. From all past experiments the addition of any foreign substance to peat seems deleterious rather than helpful.

6. Is any particular sort of boiler or grate required ?

Ans. Peat fuel will burn in almost anything, but to get its full value the grate bars should be closer together than for coal.

7. Is there much waste of the material (*a*) in producing the fuel, (*b*) in consumption with ordinary boilers ?

Ans. (*a*) No. (*b*) No. With good quality peat fuel there is little ash and little waste combustible gas.

8. In the case of Irish peat, would cheapness of production counterbalance the high cost of carriage to England ; *i.e.*, could it be delivered, say in Sheffield, at the same price as coal ?

Ans. No ; only peat made in the neighbourhood could profitably be used in such centres as Sheffield or Glasgow. But all over the interior of Ireland coal is always very dear, and peat fuel could profitably be substituted for it for use in creameries and other small local factories, and would be very welcome there for these purposes, and also for domestic use, where it could take the place of either crude peat or coal.

9. What bye-products are produced from the burning of peat fuel, *e.g.*, in furnaces ?

Ans. No available bye-products result from burning peat in a furnace ; but, if the blocks of peat fuel are turned into charcoal—charcoal of the best quality (worth now £3 10s. to £4 a ton) is obtained, with many bye-products, peat tar, etc.

B. The following information is supplied by the Scottish Peat Industries, Limited, of Racks, N.B.

The Company was formed to take over and work five patents for utilisation of peat, the invention of Mr. Allison Bell Lennox of Newcastle-upon-Tyne, Consulting Engineer, and the joint property of him and Mr. A. H. Higginbottom, of the same place. Mr. Lennox has devoted many years to the scientific study of peat and peat processes and is familiar with the German and Canadian processes, and he claims to have now perfected and patented a better process than any hitherto brought out. The fault in his eyes, of the German and other processes is that in many of them the process is very expensive, and in most of them (which make a point of bye-products) much of the valuable properties of the peat are extracted before the fuel is turned out ready for burning. Drying by pressure has not been successful, and the application of great heat alters the chemical properties of the peat. Many of the German blocks are very hard, dark coloured, and of nice appearance, but on being fired they crumble away into dust.

Mr. Lennox has had several difficulties to overcome. In the first place, peat holds so much water that the drying of it is all important. Peat is largely composed of fibre which is mostly tubular, and its capacity for taking up and retaining moisture is enormous : its reluctance to part with moisture when in a raw natural state is very marked.

Then follow details of the five patents :

(*a*) An invention for expressing moisture from peat.

(*b*) A machine for the efficient disintegration and shredding of peat in a raw state.

(*c*) A briquette making machine.

(*d*) An invention for mechanically drying by means of hot air.

(*e*) An improved lifting truck for raising or lowering loads of peat.

The company began operations a year ago, and have spent nearly £6000 on their works, which are now almost complete.

Attention has been drawn away from fuel by other and more profitable uses for peat on which a large series of experiments has been made, but the company have turned out a sufficient quantity of peat fuel to assure them that it can be done by their process at a considerable profit. Their peat fuel hitherto has been air dried without shelter, owing to the non-existence as yet of a large dryer (invention *d*). It was impossible last year to completely dry off peat in the open air, but a small dryer was put up recently on the lines of (*d*) which has dried off a large quantity in a very satisfactory way though heated only by surplus steam from the engine. It is expected that the works will be completed in a very short time, but it is impossible to say if fuel will be produced in any large quantity, as the company can make a better profit by using peat for other purposes.

Ordinary air dried peat blocks, not treated in any way, have been sold from carts in Newcastle-upon-Tyne at 5s. per 100 blocks. The company could send better blocks from Dumfries and retail them in Newcastle at less than half the above price. The company's peat blocks when put on to a coal or coke fire, or mixed with coal or coke, make a brilliantly clear fire without smoke and induce a complete combustion. They burn by themselves, but best when a little coal has been used to start the fire. Most coal grates are ill adapted for burning dry peat blocks, as the draught is too great.

It is difficult as yet to give any reliable statistics as to cost of production, so much depends upon the moss itself, its situation with regard to railway, cost of labour on the spot, and other matters. Profit is affected by length of carriage etc. Brewers and distillers will take any quantity of the company's peat fuel delivered in Edinburgh at 25s. a ton. The actual cost to us put on to trucks at the works will be about 7s. 6d. to 10s. 6d. per ton.

The works are situate on the Lochar Moss, and within 200 yards of Racks station on the Glasgow and South-Western Railway. Dumfries is distant 4½ miles. The moss is an enormous tract some 6 miles long by 2 miles wide, and 16 feet deep about 100 yards from the margin where the works are placed.

Peat has been proved suitable for the production of power gas and electrical energy, and the company have in view the supplying of power and light, not only to their own works, but of Dumfries and the surrounding places.

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C. Bulletin No. 5 of the Bureau of Mines, Ontario, 1903.

A very complete account of "Peat Fuel; its Manufacture and Use," is to be found in the above publication, from which the following extracts are taken:—

"For several years the peat fuel industry of Ontario has been gradually developing, and the point has now been reached at which the makers can turn out their products at a profit. The burden of the experiment and investigation, always an onerous one in establishing a new industry, has been borne by a few, and no doubt much money has been spent on methods and machinery which in the end gave only negative results."

"It would perhaps be too much to assert that all the difficulties have been surmounted, and that the success of the industry is an assured and established fact; but at any rate, the preliminary stage appears to have been passed, and there can be little doubt that what yet remains to be done will soon yield to the address and skill of those who have already done so much."

"We may be certain that the difficulties surrounding the production of a cheap and efficient fuel from peat will in like manner disappear; indeed, some of them have already vanished, and the question seems to be rather how to produce the best possible fuel at the least possible cost, than how to produce a good fuel at a fairly low cost."

Then follow detailed descriptions of the various processes in use in Canada.

"We are now in a position to sum up the cost of manufacturing the briquettes both at Welland and Beaverton. The totals resulting are not directly comparable because of different conditions existing at the two places. At Welland the workable depth of the bog is 3 feet, as against but 2½ feet at Beaverton, which at once gives an advantage to the former in price per ton in distributing the costs of part of the field operations; also, at Welland, the capacity of the two briquetting presses is considerably greater than that of the one at Beaverton, while at each the expenditure for labour is about the same.

"At Welland, 17½ tons briquettes per day:

	per ton.
Field Operations	$0·3771
Attendance on dryer	0·1650
Attendance on presses	0·2171
Power	0·2113
Total	$0·9705

"Wages have gone up since the Welland tests were made, and labourers now get at least $1·40 per day. This advance will add proportionately to the cost of manufacture.

"At Beaverton, twelve and a half tons briquettes per day:

	per ton.
Field operations	$0.3911
Drying	0.3673
Briquetting	0.2512
Total	$1.0096

"In neither case do the above figures cover more than actual operating costs, nothing being allowed for interest on capital investment, wear and tear of machinery, royalty, charges or profits." . . .

"In the following figures an attempt is made to include all items of cost such as those for depreciation, interest, etc., which can only be approximate:

	per ton
Manufacturing	$1.0096
Cost of bog	0.0180
Depreciation of plant	0.3483
Interest on capital	0.1741
Royalty	0.2500
Total	$1.8000

"The price at which the Beaverton product sold at the factory in 1901 and part of 1902 was $3.00 per ton. In the autumn of the latter year owing to the advance in price of all kinds of fuel, it was increased to $3.75. There was good local demand for all that could be made. At $3.00 per ton peat briquettes of good quality would sell readily in competition with coal at $5.00 per ton and upwards. From conveniently situated plants they could be delivered with reasonable railway freights and sold in cities and towns at $4.00 or $4.50 per ton at which price they would be about on an equality with anthracite at $6.00 per ton." . . .

"Peat briquettes can be made in Ontario at about $1.00 per ton of 2,000 lb. Allowing a suitable margin for profit, interest on invetsment, etc., it is evident that compressed peat fuel can be sold at the place of production for $3.00 per ton, and at a correspondingly greater figure if railway freights have to be paid. As a matter of fact, it has already been sold by one maker for two successive seasons at $3.00 per ton, and beyond doubt in this price was included a fair profit. Putting the theoretical value of peat briquettes at two-thirds that of coal, at $3.00 per ton their cost would be equivalent to anthracite at $4.50 per ton, and at $4.00 per ton to anthracite at $6,00 per ton. Such figures at once bring peat fuel into the economic arena, as it may be doubted whether with the effective control now exercised by the trusts over the production and sale of anthracite, we are likely to see it again drop to a lower retail level than $6.00 per ton."

"A firm in Ontario quotes the following prices for the machinery and apparatus required for a complete peat plant according to the Beaverton plan, with a capacity of 3,000 tons of briquettes per year, working ten hours per day, or 6,000 to 7,000 tons when run continuously twenty-four hours per day:

Briquette press	$2,500
Dryer	1,350
Breaker	400
Excavator, including motor	600
Generator, tram-car, motor and tracks	1,200
Engine and boiler, 50 h.p.	2,000
Shafting, belts and conveyors	700
Buildings (bricks)	1,500
Sundries	200
Total	$10,450

The same company also manufactures the Dickson briquetting press for $1,500, and the Simpson dryer for $1,500 or, including cost of brick work and setting up, for $1,750.

Peat Gas.—"The use of peat gas for fuel purposes is of long standing in the iron and steel industry of Sweden, in which it is preferred to coal gas on account of its much greater freedom from Sulphur and Phosphorus. At the rolling mills, peat gas is used in the plate furnaces with the result of reducing the formation of scales, particularly in the rolling of thin steel plates. The use of peat gas has contributed largely to improving the quality of Swedish steel, the excellence of which is well known. Peat gas has also come into use as fuel in steam boilers."

"Three test runs made in 1901 in Canada with the Merrifield peat-gas generator gave the following average calorific values:

(1) 133.7 B.T.U. per cubic foot.
(2) 156 " " " "
(3) 114 " " " "

"The analysis of a sample of the gas taken from the pipe at the conclusion of the calorimeter test, which also marked the end of the whole experiment, gave as follows:

	per cent.
Carbon dioxide, CO_2	20.5
Carbon monoxide, CO	10.2
Methane, CH_4	1.9
Hydrogen, H.	22.8
Nitrogen, N.	44.6
	100.0

"The quantity of carbon dioxide in this sample is larger than was obtained in samples taken in previous tests. In one there was but 12.4 per cent. CO_2, and in another but 7·4 per cent. An increase of CO_2 accompanied by a decrease of CO, such as the above analysis shows, would be caused by the lowering of the temperature of the retort at the end of the operation when the sample was taken.

"The analysis of the peat used in the experiment is as follows:—

	per cent.
Moisture	25.94
Volatile organic matter	48.41
Fixed carbon	18.69
Ash	6.96

One of the firms engaged in the peat industry gives the following figures:

"From one ton of compressed peat, analysing approximately: moisture 15 per cent, ash 7 per cent., fixed carbon 21 per cent., volatiles 57 per cent., valued at $1.50 per ton delivered at gas retort, figuring wages at 20 cents per hour, and yearly depreciation at 6 per cent. upon value of machinery, and in a plant capable of producing 40,000

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cubic feet of gas hourly, a yield will be had of not less than 100,000 cubic feet of fixed gas, carrying not less than 150 B.T.U. per cubic foot, at a cost not exceeding 2½ cents per 1,000 cubic feet. We will supply all apparatus and material for a plant producing not less than 20,000 cubic feet of gas per hour for $5,000, exclusive of freights, cartage to site and erection, larger plans proportionately. Peat carrying up to 30 per cent. moisture may be used, but the yield of gas will be reduced about 1,000 cubic feet for every additional 1 per cent. moisture."

"This estimate was made for gas plants situated at a distance from the bogs, to which the peat would have to be shipped, and which therefore must first be manufactured into compressed fuel. If the use of cut-peat be made possible by locating the gas works at the bog, or only at such distance that the peat could be economically transported thereto as cut peat, the cost of the fuel should not exceed 50 to 75 cents per ton.

"The above experimental runs with the Merrifield generator were made on cut peat, and the analytical tests show that it gives high results. With compressed peat briquettes the advantages over cut peat would be smaller bulk, and therefore less frequent handling, lower moisture content and consequently a higher calorific value.

"There are many advantages to be gained in the use of peat, by converting it into gaseous fuel, many of them appertaining equally to other gaseous fuels. While the consumption of the solid fuel involves a loss of heat of 25 to 30 per cent. or more, this loss, if the fuel be converted into gas, will be reduced to from 15 to 20 per cent. When the fire-box is sufficiently large the combustion is complete, and without smoke or soot, leaving always a clean boiler surface. A properly regulated draught insures complete and even combustion. Its comparative freedom from sulphur makes possible a long life for the boiler. A better insulation may be had against loss of heat by radiation, and the hot gases from the generator may be utilised for drying the peat which is to be converted into gas.

"The most important reason, however, why peat gas can be more profitably and extensively employed than peat in large industrial works lies in the fact that by locating a large central power station at a suitable bog the cheapest kind of peat, namely, cut peat, satisfies all requirements; and the gas may then be piped for distribution, or, if the place of consumption be at too great a distance, it may be converted at the bog into electrical energy."

Continent.—"Machine peat (which is the name given to peat ground or macerated to a pulp while wet, sometimes with the addition of water, and then cut or moulded into blocks and dried with or without artificial heat) is sold in large quantities in Holland, Germany, Austria, Denmark, Sweden and Russia, and is used not only for domestic purposes, but also in manufacturing, metallurgical, and other industrial operations. A great many steam boilers, including railway locomotives, are fired with this variety of peat, while in breweries, distilleries, and under salt-pans in Germany, it is preferred to other fuel. In Austrian glass-works and brick-yards it is also freely employed. Most of the peat consumed in Europe, except by the peasantry, is machine peat, and it forms in fact the only fuel for large bodies of the population. The methods of preparing it are very numerous, and much ingenuity has been displayed in inventing machinery and devising processes to suit varying conditions."

D.—Diplomatic and Consular Reports.

No. 2778 Sweden. May, 1902.

"Excellent machinery for the manufacture of peat for fuel and moss litter is now made in Sweden.

"The method mostly employed for manufacturing peat fuel in Sweden is that of grinding, pressing, and afterwards drying in the air, the amount of water remaining in the prepared peat being about 25 per cent.

"The manufacture of peat fuel for general consumption cannot yet be termed a success. It is carried on almost entirely on estates which have upon them large peat bogs of good quality, and where the fuel is made to supplement the use of charcoal, wood, or imported steam coal.

"There are, it appears, at least 300 such fuel works already in Sweden, and the fuel is being experimented with for all sorts of purposes, including its utilisation instead of coal for locomotives.

"The manufacture of peat fuel is conducted on sound theoretical and economical principles in Sweden, but the climate here presents many difficulties. Tried in more favoured countries it has had, and is likely to continue to show, good results on a greater scale.

"The comparative value of such fuel is stated to be about 180 lbs. peat fuel equals 100 lbs. ordinary British steam coal. It has been found that peat mixed with an equal weight of coal gives 14 per cent. better results than when employed unmixed.

"It is fully hoped that the extensive experiments which are being carried on in various directions may yet lead to satisfactory and far-reaching results."

No. 2879. Sweden. August, 1902.

"Experiments in the use of peat instead of coal, coke, or wood for railway engines and industrial purposes have not hitherto been attended with success. Only a few glass and iron works, having peat bogs within convenient reach, find an advantage in using this fuel."

No. 2845. Germany. July, 1902.

"The engineer, Stauber, a specialist in the preparation of peat, has invented a process, and the necessary machinery for carrying it out, by which all superfluous material is removed from the peat, and it can be pressed into briquettes ready for use, forming thus a fuel of more heating value than the ordinary soft coal briquettes. Their use is recommended, not only for private dwellings, but for manufactories, etc.

"The Royal Chemical Institution of Berlin gives the following analysis of the peat briquette:—

	Per Cent.
Carbon	45·14
Hydrogen	4·54
Oxygen	29·34
Ash	9·09
Heating power in calories	3,806

"The best soft coal briquettes do not contain more heating power, and some much less. One great advantage of the peat briquette is its comparative freedom from sulphur, whereas this occurs in other briquettes in quantities of from 1·04 to 2·64 per cent. Other advantages are claimed by the inventor, but these cannot be entered into here."

Abstract from American Consular Report, No. 1615, on Peat, etc., in Germany.

Compressed Peat.

The first two machines made by Mr. C. Schlickeysen, of Rixdorf, near Berlin, for a steam peat-compressing plant at Zintenhof, near Riga, Russia, were of vertical construction and turned out daily about 80,000 pieces of wet compressed peat, which were dried and used as smokeless fuel in a cloth factory. His peat-compressing plants may now be considered as standard in Germany.*

The raw peat from the bog, containing about 85 per cent. water, 13 per cent. combustible material, and 2 per cent. inorganic matter, is cut by spades and fed into a machine which tears, kneads, and mixes it to uniform consistency: it is then forced out in strips about 3 by 4 inches, on to boards, cut into bricks 10 inches long, which are then exposed to the air and in ordinary weather lose one-half of their moisture in two weeks. 21 cubic meters (35316 c. ft.) of raw turf produce 14 cubic meters of clean peat, or 7,000 wet bricks, which when dry contain 3 to 4 tons of peat fuel.

The plant, including 10 h.p. portable engine, is set up on the edge of the moor and moved backward as the peat bed is exhausted. Its cost is 18,620 marks; it employs seventeen men, besides engineer and fireman, at a total labour cost per day of 120 marks.

After air-drying on the ground, the bricks are built up like bricks in a kiln and left to dry until they contain only 15 to 18 per cent. of water, when their thermal value as fuel is 3000 to 4000 calories, which may be increased by compression into briquettes.

Peat pulp has latterly been mixed in the grinding machine with 30 per cent. bituminous coal dust, 40 per cent. anthracite culm, or 15 per cent. dry sawdust.

Mr. Schlickeysen has brought out an excavating machine which elevates peat rapidly and at a great saving of labour.

Peat Coke and Bye-products.

By the Ziegler method peat is carbonized in closed ovens, heated by gases generated in the coking process, the products from 1 kilogramme (1,000 grams or 2.2 lbs.) raw peat, being, 350 grams coke, 40 grams tar, 400 grams gas liquor, the latter yielding 6 grams methyl alcohol, 6 grams acetate of lime, and 4 grams sulphate of ammonia.

*A description of the Schlickeysen press will be found in the Colliery Guardian for March 7, 1902.

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The value of peat-coke and bye-products from 1 metric ton of raw peat is as follows :—

Description.	Value. Marks	Dollars.
1 ton (1,000 kilograms) of peat, costing, dried, 5 marks ($1.19) produces :—		
350 kilograms (771.6 lb.) peat coke -	15·75	3·75
40 kilograms (88.2 lb.) tar - - -	2·20	·52
6 kilograms (13.2 lb.) methyl alcohol -	4·20	1·00
6 kilograms (13.2 lb.) acetate of lime -	·72	·17
4 kilograms (8.8 lb.) sulphate of ammonia - - - - - -	·88	·21
	23·75	5·65

The peat coke contains no phosphorus or sulphur and has a thermal value of 6,776 to 7,042 calories, sells at 40 to 50 marks per ton, is used for metallugical purposes and for smelting iron ores, but is at present too costly for blast furnaces.

The cost of a four oven plant is 95,000 dollars, complete. A 12 oven plant complete would cost in Germany 261,800 dollars and a profit of 170,800 dollars per annum would be realised.

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INDEX.

ABANDONED COLLIERIES—
Reopening—
Costly, 9784 (22).
Necessary to work lower seams, 15746.

ACETYLENE GAS (*see* title Gas).

AFRICA—
South, Oil shale seam, yield per ton, 13353 (41).
West Coast, Petroleum production, 13353 (42).

AIR-HEATERS, advantage over economisers, 12797 (1).

AIR-MAINS, Paris—
Leakage, percentage per mile, 10495 (7), 10529.
Pressure per square inch, 10495 (7).

AIR, temperature of, suggested method of reducing, 9791.
Conditions under which possible without large cost, 9914.

ALASKA—
Petroleum, crude, proportion of bye-products yielded, 13352 (40).
Petroleum rich in volatile constituents, 13472.

ALCOHOL—
Benzol mixed with, used in internal combustion motors, 13342 (3).
Calories developed by certain quantity compared with that developed by same quantity of petroleum, 13342 (3).
Efficiency compared to that of coal, 13567.
Employed as expansive fluid in "Alco-Vapour" launch, 13428.
German Government encourage potato growing for manufacture of, 13515.
Russian Navy uses, as a source of power in boat motors, 13342 (3).
Used as evaporative agent in place of water in motor launch engines, 13342 (9), 13422.
Used in internal combustion engines and as a source of light, 13515.

ALGERIA, Petroleum wells in Oran, 13353 (50).

ALIZARIN, Demand for bye-products from which this can be prepared, 9953.

ALTENHEIM, MR. CHARLES RUDOLPH.
Evidence on preparing coal for sale and use: particularly as to coal washing machinery and coking plant, 10066-10174.

AMALGAMATION OF COLLIERIES—
Competition might be decreased and expense of administration lowered by, 11048.
Result of, to raise the standard of management and productive efficiency, 11053.

AMERICA (United States of)—
Chicago—
Central Heating Station, basis on which payment is made by customers, 16673.
Houses supplied with light and hot water from electric light station 1½ miles distant, 16651, 16660, 16669.
Coal, New River and Pocahontas, purchase of, by British Navy, 12334.
Comstock Mines—
Temperature of strata and water in, 15593.
Effect of, on Miners, 15593.
Connellsville, Coking coal nearly exhausted, 15698.
Exhaust steam utilised for heating purposes, 16256, 16391 (D), 16464, 16651.
Exports of burning oil to Great Britain, Germany, and the Netherlands, 13346 (20).
Factories, heating, method of, 16678.
Mineral Traffic—
Pennsylvania Railway—
Earnings, expenses and profits per train mile, 15624.
Gross weight of train load, 15628.
Pittsburg and Bessemer Railway—
Cost of transport per ton per mile, 15603.
Net train load, 15606.

AMERICA (United States of)—*cont.*
Natural Gas—
Boreholes placed near together, effect on supply, 11311, 11358.
Glassworks using this gas as fuel, number of, 11297, 11298.
Householders, number of, supplied with, 11297, 11343.
Iron and Steel works using as fuel, number of, 11297.
Pittsburg Wells, area covered by, 11512.
Wells—
Life of, 11392.
Pressure falling after a time, 11310.
New York, Anthracite Coal, household use of, compulsory, 16651.
Norfolk Port, 40-ton wagons dealt with at, 15565.
Offices, Mode of heating blocks of, 16746.
Petroleum:
Appalachian oil-fields rich in volatile constituents, 13529.
Pennsylvania, yield of, per square mile, 13533 (66).
Railway wagons, Large size of compared with English, conditions allowing profitable use of, 15478.
Regenerator coke ovens, towns lighted with gas from, 10136.
Wyoming, Spouting oil wells in, 13346 (20), 13368.

AMMONIA, Sulphate of (*see* Bye-products).

Analysis of Coal, a guide to selection, 15171.
Gas (*see* Gas).
Residue, Waste of coal prevented by systematic, 15268.

ANTHRACITE—
Boilers injured by, 13621.
Domestic use, size used in Ireland, 15288.
Durrow Brick Co., Price paid by for anthracite slack, 15251.
Increased production, cause of, 15742.
Irish, carbon contained in, 15289.
Kilkenny district—
Annual output, 15245.
Purposes for which used, 15247.
Royal Navy testing oil and, in conjunction in furnaces of warships, 12367.
Using small quantity in manufacture of briquettes, 16223.
Working seams, method of, 15742.
(*See* also South Wales Coalfield.)

ASH—
Percentage of, allowable in fuel used in Meldrum furnace, 15274.
Percentage in coking coal, 10085.

ASSESSMENT OF COLLIERIES, 10986.

ASTATKI or OSTATKI (*see* OIL FUELS.)

ARCHBUTT-DEELEY process of purifying boiler water, 14928.

ARGENTINE, petroleum used for a time on Great Western Railway, 13353 (59.)

ARLBERG TUNNEL, oil-fuel apparatus of Great Eastern Railway used on all engines working in, 13915.

AUSTRALIA—
New South Wales—
Oil Shale—
Gas obtained from, used to enrich coal gas, 13353 (45.)
Production of in 1901, 13346 (19.)
Sydney, spontaneous heating of coal resulting in destruction of four ships at, 14076.
South, Coorongite found in, 13353 (45.)

AUTOMATIC sorting of coal into sizes, system of, 9026.

BAINBRIDGE, MR. EMERSON.
Evidence on labour-saving appliances, 10914-11206.

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BAKU, petroleum spirit burnt to waste in, 13505.

BALLAST (*see* coke.)

BANKFOOT Coke Works, bye-products, quantities obtained from ton of coal, 9184 (6c.)

BARBADOES, petroleum production of, 13352 (32A)

BARRETT, MR. WILLIAM SCOTT.
Evidence on railway and canal traffic, 12071–12209.

BARRIERS—
Between collieries—
Advisability of, 9784 (23.)
South Wales Coalfield, 16065, 16171, 16215 (22, 23.)
Suggestions as to equitable arrangement respecting, 9873, 15789, 15901, 15971.
To prevent influx of water—9878.
South Wales Coalfield, 16066, 16173.
Waste arising from, 9784 (5, 24.)

BEAUMONT shaft-sinking machine, difficulties in working, 10957.

BEDSON, PROF. PETER PHILLIPS, M.A., D.SC.
Evidence on economies in the use of coal, especially as to the manufacture of coke, 11207–11263.

BEEHIVE Ovens (*see* Coking plant.)

BEILBY, MR. GEORGE T.
Evidence on economies in the use of coal, 9367–9631, and on the production and use of shale oil, 15056–15150.

BELGIUM—
Deepest mine in, depth of, 10804.
Societé Cocqueril Collieries, temperature of strata, ratio of increase, 15566.*

BENZENE, Russian petroleum containing, 13373.

BENZOL, used in gas manufacture, 12557, 13044, 14345.

BENZOLINE, employed in internal combustion motors, 13342 (3).

BERLIN, Lignite briquettes used in, 10058.

BERMONDSEY, lighting of streets by electric arc and incandescent lights, cost compared with Welsbach lights, 12618.

"BILLY FAIRPLAY" system referred to, 9976

BITUMINOUS Coal—
Cost compared to anthracite, 12872.
Gas produced from £1 worth of, compared to that produced from equal value of anthracite, 12874.

BLAST FURNACES—
Coal consumption, annual, 9369 (2).
Coke consumption per day, 15611.
Disinclination of owners of, to use recovery oven coke, 15708.
Efficiency of, 9456, 9567.
Energy in form of current of high potential electricity distributed from, economy of, 9369 (13).
English, form of fuel consumed in, 9369 (13).
Explosions occurring in, 14952.
Horse power wasted—
By use of steam boilers and engines in, 15597 (12).
Cleveland iron district, 15598.
Inland Iron works, Dynamic power obtainable from, annual value of, 14590.
Oil from, coal-gas enriched with, 15090.
Scotland—
Closed tops fitted generally throughout, with recovery of bye-products. 15597 (10).
Fuel, form consumed in, 9369 (13).
Steam boilers, replacement of by gas engines in, 14868.
Tar distillates from, purposes for which used, 15073.
Waste Gases—Tons of coal represented by, 15598.
(*see also* Gas).

BOILERS—
Advantages of various types of, 14710 (1a).
Belleville type.
Depreciation compared with gas producers, 13180, 13236.
Reduction of temperature effected by, 12805 (2) 12807.
Covering boilers and steam-pipes, materials used for, 14805.

BOILERS—*cont.*
Cylindrical type, reduction in number used compared with seventeen years ago, 14653.
Deposits from water in, methods of removing, 14931.
Double combustion—
Economic results as regards wear and tear, 12805 (2).
Economy of heat resulting from, 12805 (3).
Principle of, 12805 (3)
Economy in working, conditions influencing, 12796.
Efficiency—
Method of increasing, 16472.
Testing, 16473.
Size of flues influencing, 14799.
Egg-end type—
Pressure formerly worked at, 14710 (1).
Water evaporated per lb. of coal consumed, 14710 (1).
Feedwater, Heating, method employed, 14710 (1), 14728.
Firing—
Coal consumption in 1886 and 1903 compared, 14653.
Coal reduced to very fine powder, method and results of using as fuel, 10775, 10831.
Coal, small and inferior now used, 14695.
Points to be considered with view to economy, 16484.
Schwartzkopff and Wegener systems, 10775, 10845, 14916, 14922.
Gas engines worked with producer gas will eventually replace, 9550, 12755.
Gas firing of, circumstances under which advantageous, 10663.
Heat loss—
Cause of, 12805 (1) 16472.
Percentages of, in good and low class boilers, 9369 (16), 9462.
High pressure boilers—
Advantage of, 14740.
Losses by radiation, etc., compensated for by saving in use of steam, 12833.
Losses of heat and waste gases greater than from low pressure boilers, 12830.
High steam pressure possible by introduction of mild steel in place of wrought iron for manufacture of marine boilers, economy of, 12797 (3).
Improvement in type, method of ascertaining effect on coal consumption, 14653.
Improvements in steam engines and boilers, table showing, 14653.
Incrustation—
Effect of on duty, 14791.
Fuel required to compensate for, 16651
Inspection periodically by engineers of Boiler Insurance Co., beneficial effect of, 9369 (16).
Lancashire type—
Coal burnt in keeping warm out of working hours, 16327.
Effect of stress on, occasioned by very high temperatures, 12808.
Evaporative power per lb. of coal with economiser, 14653.
Fuel cost per H.P. hour, 16538.
Temperature at back of, 16274.
Materials formerly used in making, 12757.
Modern types, economy effected by using, 15597 (13).
Percentage of heat of coal turned into steam, 10654
Pressures—
In general use at collieries, 14710 (1a), 14726.
Now used, 12757.
Compared with thirty years ago, 14710 (1).
Producer gas, economies effected by use under boilers, 10778.
Radiation and condensation, attention latterly paid to, 14727.
Steam, modes of economising, 14710 (1).
Thickness of plates, limit fixed by Board of Trade and Lloyds, 12757.
Tube boilers, method of removing incrustation from tubes, 14751.
Types of—
Details concerning, 9249.
Now used at collieries, 12778, 14721.

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BOILERS—*cont.*
- Wastefulness of former types and method of working, 14719.
- Waste gases, attempts to minimise loss from by use of economisers, 12791 (2).
- Water—
  - Bad, incrustation of, caused by, 14727.
  - Evaporated per lb. of coal in 1886 and 1903, 14653.
  - Pure, method employed in producing, 14710 (1b).
  - Quality influencing type of boiler used, 14710 (1a), 14742.
- Water-tube marine boilers, tests of heat losses described, 16471, 16476.

BORNEO, Oil fuel produced in, 12278.

BOTHWELL AND BLANTYRE COALFIELD, 8743 (4).

BOURNEMOUTH, Central heating and lighting station designed for, 16651.

BRAKE HORSE POWER, Term defined, 13073, 16392.

BRAZIL, "Turfa," yield of oil per ton, 13353 (60).

BREEZE OR BALLAST (*see* Coke).

BRICKWORKS, Potteries, etc., gas, use of instead of coal in, 9430 (7).

BRIQUETTES—
- Coal—
  - Admiralty briquettes made from small steam coal and anthracite, 15999.
  - Advantages claimed for, 9744, 10407.
  - Anthracite duff—
    - Small quantities only can be used in manufacture of briquettes, 15917.
    - Use in manufacture unsatisfactory, 15788.
  - Bad coal used in making has injured trade, 9970.
  - Baird & Co., Messrs. William—
    - Annual output, 8743 (75).
    - Cost of manufacture and selling price, 8743 (75.)
    - Size and weight of, 8743 (75.)
  - Brown coal briquettes—
    - Bonn, manufactory for, 16913.
    - Holland, manufacture carried on, 10031.
    - No binding medium required in manufacture, 10112.
  - Cardiff—
    - Fuel made in, buried for 35 years, result of analysis after excavation, 10363.
    - Pitch, percentage used in manufacture, 10363, 10452.
  - Cardiff and Swansea making best quality fuel, 10369.
  - Coke breeze made into briquettes at Continental Gasworks, 9989 (12.)
  - Coke dust, results of making into briquettes, 9643.
  - Cost of manufacture, 9744, 9989 (11.)
  - Deterioration very slight, if any, 9989 (5), 10046, 10062, 12532.
  - Distillation, partial, adopted in manufacture of smokeless briquettes, 9369 (22.)
  - Domestic use—
    - Forms most suitable for, 9396, 9527, 10399.
    - Manufactured abroad, 10105.
    - Objectionable for, in towns, 10002.
  - Dry coal, more cementing material required than with bituminous, 9620.
  - Drying process practised on the Continent tends to reduce quantity of pitch needed, 10054.
  - Exports—
    - Purposes for which used, 9989 (2).
    - Total in 1902 from the United Kingdom, 10363.
  - Germany—
    - Berlin, Lignite briquettes used in, 10058.
    - Briquette industry in, 9400.
      - Causes stimulating, 16838.
    - Cologne, manufactory making brown coal briquettes, 16913.
    - Demand for briquettes in, 10107.
    - Domestic consumption, percentage of total output, 10938.
    - Process of manufacture, 16838.
      - For lignite, 16839.

BRIQUETTES—*cont.*
- Coal—*cont.*
  - Government contracts for, stipulation as to ash, 9744.
  - Hartridge type—
    - Advantage claimed for as heat producer, 13431.
    - Constituents of briquettes, 13342 (12), 13433.
  - Heating value of briquettes containing 25 per cent. of petroleum compared with that of same weight of steam coal, 13579.
  - Italian railways using largely, 10042.
  - Lignite or brown coal briquettes, open tube presses used in Germany for manufacture of, 16839.
  - Liverpool, increasing demand for steam-raising briquettes in, 9945.
  - Manufacture of—
    - Improvements in, consideration by committee of experts suggested, 9627.
    - Not generally associated with collieries, 9989 (4).
    - Process described, 8743 (75), 9989 (8.)
  - Manufacturing firms buy unwashed coal, 9989 (4).
  - Markets for, 9989 (3).
  - Materials used in mixing, 9750, 9768, 9824, 10005, 10049,
    - Pitch 9989 (10) 10452.
  - Monmouthshire, factories at ports using Glamorganshire coal in making, 10281.
  - Newport, Cardiff and Port Talbot manufactories, quality of coal used, 10363.
  - North-east of England, causes of failure in manufacture, 9636 (2).
  - Output, annual, in England, 9989 (2).
  - Ovoid form—
    - Bunker storage, shape unsuited for, 10481.
    - Cost of manufacture compared with rectangular, 10029.
    - Difficulties in manufacture, 10106.
    - Made in South Wales and on the Continent, 10013, 10019.
  - Perforating, difficulties connected with, 10033.
  - Petroleum used in manufacture, 9824, 10049.
  - Pitch—
    - Percentage used in manufacture, 9989 (10) 10452.
    - Substitutes for in manufacture, 9750, 9768. 10005, 10049.
  - Plant, cost of, 9744, 9745.
  - Price—
    - Compared with those of some foreign countries, 10009.
    - Should be reduced to create large demand, 10021.
  - Royal Navy, Special requirements as regards smokelessness, 9613.
  - Scotland—
    - Annual output, 8783.
    - Coal dross from which made, quality of, 8784.
    - Manufacture of, would enable working of untouched seams, 8786.
  - Shape and size of, 9948, 9971, 9998, 10000.
  - Slack, washed, used on the Continent in manufacture of, 9989 (1) (7).
  - Small non-coking coal can be profitably employed in making, 9989 (5)
  - Smokelessness, experiments relating to, 12321.
  - South Wales, Exports for 1902 from Cardiff, Swansea, Port Talbot and Newport, 10363.
  - South Wales (Western Division), seams formerly unworked now extensively worked for manufacture of briquettes, 15762.
  - Space occupied by, compared with coal, 9989 (5)
  - Steam-raising—
    - Evaporative value compared with coal (5).
    - Qualities of coal used in making, 10404.
    - South Wales the principal manufacturing centre of, 9989 (3).
  - Stokers, health formerly affected by briquettes, 12490 (12).

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BRIQUETTES—*cont.*
Coal—*cont.*
Straw in conjunction with petroleum and coal used in making, 13342 (12).
Swansea—
Chief centre of briquette industry, 10474.
Pitch, percentage used in making, 10363, 10452.
Quality of coal used, 10363.
Value reduced by excess of pitch, 8786.
Varieties made on the Continent, 10104.
Weight of, 9989 (9) 9990.
West Indies, special weight briquettes made for, 9990.
Peat—
Addition of oil in manufacture, result of, 16835.
Admixture of other materials in process of manufacture unnecessary, 16820.
Analysis, 16933.
Calorific value compared with lignite briquettes. 16993.
Cleanliness of, 16987.
Close fire bars necessary when burning, 16827.
Cost of manufacture per ton, 16909, 16975.
Factory turning out 800 tons per week, cost of construction, 16974, 16990.
Germany—
Cost per ton at works, 16808, 16871.
Size of, as manufactured in, 16914.
Holland, Griendstveen Moss Litter Co. making, 16916.
Manufacture, difficulties attending, 16803.
Manufacture on small scale commercially impracticable, 16957.
Open bar compressor for making described, 16936.
Peters' manufactory at Stettin, 16799.
Plant for manufacture, costliness of, 16802.
Pressure used in making, tons per square inch, 16912.
Shapes of, 16860.
Smokelessness, 16822.
Compared with Welsh coal, 16927.
Tullamore, Ireland, manufactory at, 16798.
Yield in briquettes per ton of peat, 16930.
Petroleum—
Hartridge, advantages of, 13342 (2), 13431.
Sewage sludge used in making, 13583.
(*See also* Royal Navy, Patent Fuel, and Appendix).

BROWN COAL, briquettes manufactured from near Bonn, 16913.

BUILDINGS, Pillars for support of, proportion of coal necessary to be left in, 9784 (20), 15898.

BURMAH, Oil fuel produced in, 12287.

BURSTALL, PROF. F. W., M.A., M.I.C.E., M.I.M.E.
Evidence on the transmission and production of producer gas, 10495–10694.

BYE-PRODUCTS—
Ammonia, Sulphate of—
Demand for, leading to development of bye-product extraction, 9032.
Limit, lowest economical of plant, 12879, 12924.
less than 3,000 H.P. not advisable, 10501, 12924.
Nitrate of soda competing largely with, 9625.
Price of, 8944, 9070, 9127, 9499, 9688, 13206.
Production, annual, in tons, 9028, 9625.
Profit from sale of, reduces coal bill to almost nil, 12882.
Proportions respectively produced by gasworks, coke ovens and shale works, 9066.
Quantity recovered from a ton of coal by Mond process, 15093.
Value of, 10496.
Recovery, method of, 8743 (48).
Recovery of, does not purify blast furnace gas, 14562.
Temperature of retort influences recovery of, 10495 (3).
Uses and markets for, 8743 (57), 10497.
Benzol, Crude—
Products obtained from, 8743 (50).
Recovery ovens, installation of, affecting price of, 9081.
Uses and markets for, 8743 (62).

BYE-PRODUCTS—*cont.*
Coal, description of, giving highest yield, 8908 (16) 8959.
Creosote, Uses and markets for, 8743 (60).
Gases, method of treating, 8743 (47).
Method of obtaining from gases given off by coal in process of coking, 9184 (6c).
Monmouthshire Coal, results obtained per ton of coal coked in Semet-Solvay oven, 10305.
Naphtha, Uses and markets for, 8743 (63)
Naphthaline, Uses and markets for, 8743 (61).
Pitch, Uses and markets for, 8743 (59).
Price, fall in 9080.
Recovery much neglected, 10309, 10320.
Recovery of, affects quality of coke, 9938.
Tar—
Products obtained from, 8743 (49).
Uses and markets for, 8743 (58).
Value per ton of coal, 9634 (15) 10094.
Value per ton of coke, 8908 (18. 19) 8959.
Volatile matter in coal used governs yield of, 8908 (18).

CALIFORNIA, Petroliferous districts, situations of, 13392.

CALUMET AND HECLA MINE, Temperature cooled by proximity of Lake Superior, 10806.

CANADA—
Enniskillen Oilfields, fresh supplies accumulating after exhaustion by pumping, conclusion deduced from, 13403.
Gaspé oil wells, supply limited, 13352.
Peat fuel manufacture in Ontario, causes stimulating progress of, 16840.
Peat, method of cutting, 16844, 16850.
Petroleum, chief source of supply, 13351 (27).
Tar sands—
Bitumen, proportion contained in cubic foot, 13352 (36).
Cubic miles of bituminous sands in sight, 13352 (36).
Distance from railway prevents utilization of, 13470.
Theory accounting for presence of, 13377.

CANALS—
Aire and Calder, Competition in coal trade with railways assisted by system of box boats and hydraulic machinery, 11980, 12018.
Leeds and Liverpool—
Carriage of coal, cost per mile, colliery owner finding boats, horses, etc., 12205.
Coal traffic into Liverpool—
Formerly carried by, 12189.
Not much used for now, 12118.
Disuse of, changes wrought by, 12208.
Subsidence of, through getting out coal under, 12203.
Water from, entering mines, 12122, 12195.
Sankey, practically useless as coal canal, 12122.
South Wales, water supply in canals insufficient for carrying large amount of coal traffic, 12019.

CANNEL COAL, rise in price leading to diminished use in gas manufacture, 9369 (20) 12555.

CAPITAL INVESTED IN COAL MINES, Return upon during last fifteen years compared with previous fifteen, 11145.

CARBON—
Bi-sulphide of, substitute for coal in production of power, 16244.
Coking coal, average production of carbon contained in, 10084.
Dioxide, Valueless as producer of heat or power, 10517.
Monoxide—
Compression possible without danger of self-ignition when diluted with large proportions of inert gas, 14492.
Intrinsic advantages of, 14492, 14519.
Pressure curve compared with that resulting from burning of hydrogen or hydro-carbons, 14492.
Value as thermal agent in internal combustion engines, 14488.
(*See also* Coking Plant.)

CARMARTHEN COALFIELD (*see* South Wales, Western Division, Coalfield).

CARNEGIE, Mr. ANDREW, Natural gas used by, in iron works, 11267.

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CASEIN, Petroleum solidified by means of, 13342 (13).

CASPIAN SEA, Steamers propelled by oil engines only used on, 13342 (11).

CENTRAL ELECTRIC POWER STATIONS (*see also* Electric Power).
- Blast furnaces, power potential of inland, 14588.
- Competition with engines in mills or factories impossible, 16535.
- Cost of installation for 25,000 I.H.P. with gas producers and dynamos driven by gas engines, 13069, 13090.
- Lancashire slack, consumption per kilowatt hour, with load factor of 25 per cent., 13081.
- Motor load factor, variations in, 13075.

CENTRAL HEATING INSTALLATIONS—
- Board Schools, Relative fuel consumption in three, heated by different methods, 16632.
- Bournemouth-Boscombe scheme, 16651.
- Cost compared with that required to maintain an equal temperature with open grates, 16625.
- Dryness of air obviated by humidifier, 16626.
- Economies in connection with plant, 16753.
- Economisers, proportion of fuel saved by, 16758.
- Economy in fuel resulting from use of, 9571, 16618, 16651, 16750.
- Electric lighting station supplying houses with hot water for heating purposes by means of exhaust steam from engines, 16651.
- Health, beneficial effect on, 16748.
- Hot air system of heating, fuel suitable for use in furnace, 16737, 16743.
- Open fires not required where installed, 16627.
- Prejudice against, cause of, 16618, 16627, 16745.
- Small houses, economy possible by substitution of central heating for open fires, 16627.
- Test of installation heating 35 rooms, 16618.
- Ventilation—
  - Adequate, can be combined with, 16627.
  - By mechanical means does not increase fuel consumption, 16636.

CHARCOAL, Peat, advantages of, for metallurgical purposes, 16920.

CHEMICAL, Glass and Cement works, Potteries, etc.; Annual coal consumption, 9369 (2.)

CHEMICAL WORKS, Coal consumption of Lancashire slack per kilowatt per hour with highest form of steam plant compared with Welsh and bituminous coals, 13079.

CHENHALL & CHENHALL, Messrs., Solidified petroleum produced by, 13342 (12.)

CHIMNEY GAS, Analysing as a means of controlling combustion, 9530, 15099.

CHINA—
- Natural gas—
  - Life of wells, 11392.
  - Used in salt manufacture for over 1,000 years, 11298 (5.)
- Petroleum yield from brine wells, 13353 (63,)

CHURCHES, heating with hot air, 16688, 16696, 16722.

CLAY—
- Belgian, Analysis of, 9050, 9109.
- Refractory, British clay bricks, varying temperature of retort ovens affecting, 9042.

CLEVELAND IRON TRADE, Heat wasted in, tons of coal represented by, 15598.

CLIFT OR STRONG SHALE, 16081.

CLOD, Hard clay disintegrating quickly on surface, 16136

COAL-BREAKERS used at Collieries in Carmarthen Coalfield, 16215 (26.)

COAL—
- Cargoes of—
  - Loading, systems of, 11994, 14129.
  - Ventilating tubes through, cause firing, 14130,
  - Wet coal, Board of Trade rescinded regulation compelling discharge of, 14124.
- Cleaning, Methods tried other than washing, 10165.
- Consumption of—
  - Gas-making, influences tending towards reduced, 12721.
  - London, approximate annual amount, 13309.
  - Statistics showing quantities consumed in various industries; publication advocated, 9501.
- Dust—
  - Combustion of, practically complete, 12856.
  - Smoke from, can be completely done away with, 12860.

COAL—*cont.*
- Full value of—
  - Future economy depends on getting, 8885, 8907.
  - Not now obtained, 13523.
- Getting—
  - Cost now compared with thirty-five years ago, 11105.
  - Cost of, conditions influencing, 9784 (44).
- Output—
  - Cost of production—
    - Depth of working influences, 10976, 11009, 15484.
    - Increase from all causes during the past fifteen years, 11155.
    - Increase in during the last fifty years, 11168.
  - Production per man, conditions influencing, 9784 (38).
  - United Kingdom—
    - Annual. 9369 (2).
    - In 1871, 15595 (1).
- Price of—
  - Circumstances influencing, 11003.
  - Rise in, effect of, 9630, 15318.
- Quality of, differences in same seam, theory for, 15816.
- Resources of—
  - Economies in—
    - Gas as producer of power and heat in factories in place of coal, 11909.
    - Petroleum used in internal combustion engines for steam raising, 13518.
    - Picking belts and cleaning installations prevent waste of coal in gobs, 9949.
  - Probable duration of, 11135.
  - Scarcity of cheap coal threatened, 15672.
- Storage of, spontaneous combustion in stacks of coal, means of preventing, 14136.
- World's output in 1891 compared with petroleum production in same year, 13353 (67.)

COAL COMMISSION of 1866–1871, 11136.

COAL-CUTTING MACHINES—
- Abandoning use of, reason for, 11169.
- Advantages of, 11154, 17096.
- Champion—
  - Cost of, 17105.
  - Efficiency, conditions ensuring, 17240.
  - Fixing, mode of, 17237.
  - Percussive type, superficial feet cut by, in 8 hour shift, 17188.
  - Use in long wall face, 17200.
- Choice of, conditions influencing, 17050, 17118.
- Coal faces, extension of in given time by machine and hand labour compared, 17099.
- Compressed air as motive power, coal consumption per superficial foot holed, 17082, 17142.
- Conditions—
  - Rendering use of advantageous, 11088.
  - Rendering use of impossible, 11084.
  - Restricting use of, 10767, 10918.
- Cost of, 17100.
- Diamond—
  - Driven by compressed air and by electricity, cost compared, 17106.
  - Number of men required to work, 17042.
  - Rotary disc type, weight of, 17027.
- Difficulties with machines, cause of, 17116.
- Disadvantages of, 17109.
- Electricity as motive power—
  - Advantages compared with compressed air, 17138.
  - Coal consumption per superficial foot holed, 17082, 17142.
  - Speed compared with compressed air, 17040.
- Gillott & Copley—
  - Number of men required to work, 17042.
  - Weight of, 17027.
- Ingersoll—
  - Cost of, 17105.
  - Holing, depth and mode of, 17076.
  - Number of men required to work, 17076.
  - Superficial feet of work cut in 8 hours' shift, 17076.
  - Weight of, 17076.
- Labour connected with, method of payment for, 11117.
- Large coal got by, proportion compared with that got by hand labour, 10926, 17096.

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COAL-CUTTING MACHINES—*cont.*

Lidgett Colliery, Coal all got by machines, 10764.
Men earn more by using machines than by hand labour, 10925, 10927, 17228.
Miners in this country get same price for coal holed by machine or hand, 9866.
Output by Diamond and Gillott & Copley compared, 17030, 17043.
Park Mill and Emley Moor Collieries—
Large and small coal, proportions obtained by machine compared with hand labour, 17180.
Length of face cut by machine electrically driven in certain time, 17153.
Working, method of, 17148.
Physical conditions in Great Britain compare unfavourably with those in America with regard to use of, 11157.
Pneumatic chisel type, method of working, 11172.
Profitable working of mines in the future will greatly depend on use of, 9866
Qualities indispensable in, 17124.
Quantity of coal obtained from given area by machines compared with hand labour, 17094.
Safety of miners secured by using, 17133, 17174.
Saving effected by use of, 10769, 10921.
Size and value of coal increased by use of, 10771.
Stanley type—
Made in different sizes, 11182.
Method of working, saving resulting from, 10940
Successful use of, 9784 (27) 17124.
Thickness of seam limiting use of, 10761.
Thin seams—
Economy of using, quality of coal influencing, 17197.
Minimum thickness profitable, 9980.
Seams under two feet nine inches thick, Champion heading machine suitable for, 17078.
Under cut of Diamond Rotary and Gillott & Copley, 17032, 17043.
Wharncliffe Silkstone Colliery—
Electrical power used for driving machines, 10887.
Seams worked by machinery, 10885.

COALFIELDS—

Concealed—
Derbyshire and Nottinghamshire field, area of, 10879.
Doncaster District, 10793.
Lincolnshire (South Carr), 10789, 10815, 10817.
Durham, Coke, annual output, 15596 (7).
Forest of Dean, character of coal produced, 10217.
Glamorganshire, character of coal produced, 10217.
Lancashire, mountain mines, 9743.
Lanarkshire—
Coal seams left unworked, 8786, 8847.
Coal, sizes into which separated, 8743 (28.)
Coal screening and washing plant replaced by modern arrangements (W. Baird & Co.) 8743 (21).
Deterioration of coal, 8842.
Ell seam, inferior bands left unworked, 8743 (73).
Hirst or Shirva seam unworkable through poorness of coal, 8743 (73).
Miners' wages, basis of calculation, 8864.
Semi-anthracite coal, percentage of fixed carbon in, 8743 (72).
Strata intersected by whinstones, 8743 (72).
Washing coal, loss by, 8860.
Working hours, 8833, 8743 (22).
Monmouthshire—
Ash, percentage of in coal, 10223.
Bye-products—
Recovering, financial aspect of process, 10308.
Semet-Solvay oven, results obtained per ton of coal coked, 10305.
Climatic conditions influence colliery working, 10347.
Coal rich in bye-products, 9121.
Coke—
Annual production, 10248.
Exports, 10255.
Market for, 10389.
Distance from pits to Newport Docks, 10213.

COALFIELDS—*cont.*

Monmouthshire—*cont.*
Export of coal—
Coal-tax affects quantity exported, 10284, 10466, 10485.
Small coal, exports of, 10427.
Freights to Hamburg from, 10431.
Labour question effect on colliery working, 10347.
Lower measures, steam coal, percentage of volatile matter contained in, 10343.
Miners—
Restless spirit among, causes labour difficulties, 10349.
Wages, mode of payment, 10421.
Nut coal, value for steam raising purposes compared with large coal, 10300.
Output—
Annual production, 10180.
Foreign markets for, 10276.
Germany uses coal for coking, 10278.
Purposes for which used, 10212.
Railway rates from pits to various ports, 10219.
Semi-bituminous coal the principal production, 10181.
Small coal—
Bye-product recovery in retort ovens from, result of practical experiment, 10332.
Deterioration by keeping, 10356.
Markets for, 10411, 10427.
Nuts, percentage obtained from, 10272, 10335.
Peas or beans, percentage obtained from, 10272, 10335.
Price of (1903), 10288.
Proportion brought to the surface, 10182, 10185.
Rubbish, percentage obtained from, 10272, 10335.
Slack or dust, percentage obtained from, 10272, 10335.
Small, nuts and peas, prices at pit in 1902, 10271, 10335.
Total annual—
Production, 10383.
Weight sold or exported, 10458.
Upper measures, volatile matter contained in household coal, percentage of, 10343.
Varieties of coal produced, 10177.
South Wales—
Analysis of coal carried out by Geological Survey Department, 12354.
Coaling of ships delayed by trimmers, 11923.
Deterioration of coal, 11932, 12326.
Exports, annual, including bunker coal for English ports, 11916.
Foreign markets for, 10363.
Output, annual, from all collieries, 11916, 12234.
Position of collieries prevents banking of coal, 10354.
Railway wagons—
Collieries supply own, 11918.
40 ton wagons unsuitable for trade in, 12024.
Must be interchangeable, 11930.
Time occupied by return journey from collieries to various ports, 11924.
Shipping appliances—
For bunkers and cargoes compared, 11976.
Improvements in, result of, 12023.
Shipping coal, methods practised, 11994.
Sidings, difficulties concerning would be diminished by use of larger wagons, 11949.
Slack left in pits may be utilised, 9773.
Small coal—
Principally gobbed, 9724.
Steamers using as bunker coal, 10380, 10392.
Steam coal—
Character of, 11933.
More valuable for shipping trade in large lumps, 12050.
Rapid exhaustion of best seams, 12343.

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COALFIELDS—*cont.*
South Wales, Western Division—
Abandoned workings, coal lost by, 15761.
Analysis of coal, 15735.
Anthracite field—
Cleavages, distance between, 16056, 16187.
Coal gobbed, proportion of, 16163.
Left behind in seams, proportion of, 16144.
Collieries working, total output in 1902, 15741.
Fixed carbon, proportion of, contained in coal, 15741.
Flooding of small area through imprudent mining, 15762.
Getting coal, how paid for, 15743.
Large coal—
Proportion sent out, 15743, 16054.
Quantities available, 15738.
Method of working, result of change in, 15954, 16097.
Order of working seams, effect on other seams, 16146.
Seams—
Area occupied by, 15737.
Generally worked on mountain sides first, 16205.
Section of field, 16143.
Sizes into which coal is separated, 16080.
Small coal, proportion gobbed, 15744.
Specific gravity of coal, 15853, 16111.
Thickness of seams, 15743, 16045.
Tons per foot thick per acre, 15855.
Volatile matter in coal, 15733.
Area unlet available only by deep sinkings, 15744.
Barriers—
Absence of, causes waste of coal through influx of water, 15765.
Difficulties caused by former neglect to leave, 15761.
State control of workings suggested, 15761.
Big Vein, mode of working, section and yield per foot thick per acre, 16080, 16092.
Bitumen, quantity in coal, ratio of decrease in relation to depth, 15737.
Bituminous area—
Seams, area occupied by, 15737.
Situation of, 15761.
Small coal all sent out, 15994.
System of working, 15761.
Volatile matter in coal, 15733.
Winning, method of, 15761.
Carmarthen District—
Anthracite got by blasting, 16215 (17, 21)
Coal left behind in workings, proportion of, 16215 (18).
Inclination of seams, 16215 (16).
Nuts, collieries generally manufacturing, 16215 (26).
Order of working seams, 16215 (30).
Seams worked, names and thickness, 16215.
Small coal—
All sent out from seams worked by longwall system, 16216.
Price paid for filling, 16215 (18).
Yield per foot thick per acre, 16215 (19).
Coal—
Gobbed, proportion, 15744, 16059.
Left behind in seams, could be recovered, 16170.
Coal Measures, Upper and Lower Pennant, thickness of, 15733.
Colliery consumption of coal, 16107, 16175.
Crasissa vein, mode of working, section and yield per foot thick per acre, 16080, 16092.
Culm partly gobbed, 15743.
Depths at which coal of various qualities is to be found, 15738.
Dryness of coal increases with depth, 15733.
COALFIELDS—*cont.*
South Wales, Western Division—*cont.*
Faults, number and effect of, 15741.
Filling, method of, 15743, 16129.
Flooding of large areas occurring through disagreement of adjoining lessees as to pumping, 15762.
Fork used for filling coal, distance between prongs, 16131.
Geological formations covering coal measures, 15732.
Large and small coal, relative yields, 15746.
Longwall system—
Adoption in steep seams, economy of, 15761.
Proportion of coal lost in working by, 15765.
Pembrokeshire, anthracite contains very small portion of volatile matter, 16006.
Pennant series, quality and uses of coal, 15746.
Pillar and stall system—
Proportion of coal—
Got in first working, 15839.
Lost in working, 15765.
Pillars—
Loss of coal by, 15761.
Relative loss of coal in thick and thin seams, 15746.
Size of, 15842.
Quality of coal, changes in, 15733.
Red Vein, mode of working, section and yield per foot thick per acre, 16080, 16092.
Screens, size of mesh, 15748.
Seams—
Inclination of, 15733.
Number of on north side, 15733.
Order of working, 15762, 16044.
Thickness of workable coal on north and south sides, 15733.
Semi-bituminous seams, area occupied by, 15737.
Small coal—
Gobbed—
Tendency now to wash and send out coal formerly, 15824.
Would not be, if market at fair price could be found, 15915.
Proportion filled into trams with large, 16087.
Soft coal seams, filling, method of, 15743.
Stanllyd Vein, mode of working, section and yield per foot thick per acre, 16080, 16092.
Steam coal area—
Firing of coal by spontaneous combustion, effect of, 15762, 16022.
Getting coal, how paid for, 15751.
Order of working seams, 15752.
Small coal all sent out, 15994.
System of working adopted, 15746.
Upper or Pennant Measures only won, 15746.
Volatile matter in coal, 15733.
Strata, thickness on north and south sides, 15733.
Swansea or Dulais Valley District, Big or Ninefeet seam, proportion of large to small coal, 16055.
Systems of working practised, 15743, 15746, 16049, 16158.
Thick seams—
Method of working, 15821, 16049.
Thinning down, 15743.
Thin seams, thickness of those worked, 16018.
Through and through filling, economical effect of, 15744.
Varieties of coal met with, 15732.
Water in workings, quantity comparatively small, 15744.
Workings, general character of, 15744.
South Yorkshire—
Annual output, 15309.
Area defined, 15323.

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COALFIELDS—*cont.*
South Yorkshire—*cont.*
Barnsley Bed—
Average thickness, 15530.
Character of, 15527.
Method of working, 15528.
Seam splits up east of Carlton, 15533.
Seams overlying, workable at future date, 15525.
Development of, 15311.
Distance from markets a disadvantage, 15303.
Geological formation, 15520.
Goole, trade with, 15455.
Largest area of unworked and undeveloped coal field comprised in, 15301.
Opening up of new collieries in east and south, 15426.
Railway rates—
High, effect on trade, 15331.
Service to collieries, 15539.
Wagons, collieries owning all used, 15488.
Seams—
Below Barnsley Bed, proved to Manvers Main, 10809, 10814.
Eastern seams show no deterioration, 10873.
Small Coal, preparing for sale, improved methods, 15315.
Steam coal—
Equal to Welsh, except as regards smoke, 15463.
Proportion got compared to total output, 15313.
Storage space required compared with Welsh coal, 15467.
Varieties of coal produced, 15312.
Stirlingshire—
Carboniferous Limestone or Lower Coal Measures, Depth and quality of coal, 8743 (5).
Dross, purpose for which formerly used, 8743 (14).
Geological position of field, 8743 (3).
Wigan—
Arley Seam—
Depth of, 9744.
Temperature of—
Return air, average, 9900.
Strata, ratio of increase in relation to depth, 9889.
Coal abandoned in consequence of water, central pumping station suggested, 9755.
Gannister Seam, Working, mode suggested, 9756.
Mines considered unworkable, suggestions as to rendering coal marketable, 9743.
Nine feet seam—
Coal gobbed, proportion of, 9811.
Percentage of ash in coal, 9800.
Section of seams, 9743.
Thin seams, large area worked below Mountain Mines, 9751.
COAL MINES REGULATION ACT, 1887.
Deposit of plans under, 15867.
Dirt in coal, vagueness of clauses concerning, 8743 (31).
COAL SMOKE ABATEMENT SOCIETY—
Supported by voluntary subscriptions, 13245.
Tests of grates made by, explanation of chart showing results explained, 13327.
Work of, 13244, 13250.
COAL SMOKE—
Abatement of—
Grates, smoke consuming—
Government architect watching tests of various types, 13281.
Government putting in, in new offices, 13280.
Local Authorities refuse to enforce law concerning, 13300.
Local Government Board refuse to take action against local authorities failing to enforce Smoke Abatement law, 13305.
Office of Works prosecution of owners of factories at Brentford for producing smoke, 13304.
Authority to deal with the emission of smoke from domestic and other grates, suggested appointment of, 13338.
Emission of smoke causes waste of fuel, 13251.
Factories the principal cause of London smoke, Sir W Richmond's views concerning, 13285.
COAL SMOKE—*cont.*
London daily waste of unconsumed carbon, weight of, 13263.
Remedies suggested—
Anthracite coal, domestic use of, 13265.
Central heating of buildings, 13283.
Coke, domestic use of for heating water, 13269.
Gas, domestic use of for cooking, 13267.
Grates, legislation advocated compelling use of smoke-consuming types, 13276, 13336
Oil, domestic use of, for cooking purposes, 13274.
Sunlight lost in London through smoke, estimate of Meteorological Office, 13331.
Test of quantity of smoke emitted from chimney, how made, 13339.
COAL TAX—
Advantage of, to nation, 10485, 10494.
Effect on Monmouthshire export trade, 10467.
Exemptions from, 10287, 10291.
Export of coal affected by, 10284, 10466, 10485.
COAL TRADE—
Development of, difficulties arresting, 10969.
Financial position of, 10970.
Lancashire—
Coaling dock required at Liverpool, 12168.
Larger Wagons might be used, 12135.
Ultimate destination of coal unknown to colliery owner, 12129.
COAL UNDER TOWNS—
Enfranchisement, under State control, of agreed areas suggested, 15765.
Working possible only if small owners unite and field is worked as one property, 15946.
COKE—
Ash in coke made by Messrs. Pease and Partners, 9349.
Ballast or breeze—
Formation in coking process, measures taken to prevent, 9634 (9).
Uses for, 9634 (9) 9646.
Beehive coke—
And recovery oven coke, iron smelters' experiments with, 9737.
And retort oven cokes compared, 9232.
Preferred by iron-masters, 8743 (42), 8771, 8808, 9939, 11261.
Prices compared, 9675, 10259, 10335.
Blast furnace coke, further study of constituents of coal and their qualities at various temperatures necessary for manufacture of, 9369 (21).
Bothwell Castle Colliery—
Price realised for coke, 8743 (43).
Sizes into which coke is divided, 8743 (43).
Two qualities of coke made, 8896.
Coal—
Charged into ovens, percentage of moisture contained in, 9200.
Containing high percentage of natural water unsuitable for manufacture of coke, 8851, 9116.
Mixed for coking, fineness of grinding essential, 9702, 9706.
Coking coal—
Coke obtained from, percentage of, 10087.
Volatile constituents, percentage of, 10086.
Coking efficiency of coal, testing, 9636 (1).
Colliery buying coal to mix for coking, 9735.
Compressed coke and beehive coke, prices compared, 8908 (21), 8964, 9058.
Compression of coal for manufacturing, result of, 8781, 8908 (13), 8951.
Compressors, cost of, 10101.
Consumption, annual, by pig iron makers, 15597.
Coppée oven coke compared with beehive oven coke, 9939.
Density of, cannot be too great, 9683.
Dry coal—
Coke manufacture from, method of, 9636 (1).
Hundred lbs., products of distillation in gas retort 11245.
Durham and Northumberland Coalfield—
Annual production, 9634 (4).
Coal now considered unsuitable for coking could be made suitable by washing, 15706.
Loss of coke annually through wasteful processes, figures showing 9636, 9674.
Economy consequent on coking all coal, 10093.

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COKE—*cont.*

English coke relatively dearer than foreign, 15597 (9).
Exporting, undesirability of, in view of limited supply of coking coal, 15655.
Germany, coke separated into sizes, 10151.
Hard coke from recovery ovens, manufacture using, 9369 (23).
Increased manufacture, cause of, 14716.
Lean coal, method of coking, 9266.
Moisture contained in coal, effect on coking properties, 9116.
Monmouthshire Coalfield—
Admixture of coal from upper and lower measures suggested in coke manufacture, 10344
Export, 10255.
Purposes for which used, 10254.
Non-coking coal—
Processes for making coke from, 9636 (1).
Rich coal mixed with, in certain proportions, enables manufacture of coke, 10097.
Treatment of, 9266.
Patent coke, meaning of term, 8962.
Patent ovens, prejudice of iron-founders against coke made in, 8743 (65).
Pease & Partners' Collieries—
Coal, tons carbonised, 1902, 9184 (2).
Coke, production, 1902, 9184 (2).
Preparing coal for manufacture, mode of, 9937.
Production—
Annual, in United Kingdom, 8946, 9369 (33), 15596 (17).
Average in Beehive, Simon-Carvès and Semet-Solvat per 100 tons of coal, 10263.
In this country cheaper than importing, 15088.
Products of Simon-Carvès and Beehive ovens compared as to hardness, 9296.
Proportion produced per ton of coal, 8768.
Quality has deteriorated since twenty years ago, 15597.
Recovery oven Coke—
Blast, strength of, influencing production of iron, 9634 (13) 9671.
Production in 1899 and 1902, 9369 (23).
Retort oven Coke—
Prejudice against, 9232, 9341.
Price realised, 9322.
Refractory nature of, 9634 (14).
Simon-Carvès Oven Coke—
Compared as to selling price with Beehive coke, 9941.
Produced by, character of, 9184 (6c).
Small coke, price for, higher than for large coke, 10153.
Small and inferior coal now used in manufacture by means of compression in retort ovens, 14716.
Value of product of recovery and non-recovery ovens compared, 10434.
Waste of, if oven not drawn when ready, 9264.
Yields with similar coals from same kind of oven varying, causes of, 9713.

COKING PLANT—
America, towns lighted with gas from regenerative coke ovens, 10136.
Beehive Ovens—
Carbon lost in, percentage of, 10083, 10091
Coals with low percentage of volatile matter coke economically in, 8983.
Coke—
Average production per 100 tons of coal, 10263.
Cost of production per ton of washed coal used, 10267, 10337, 10439.
Coking process, time occupied by, 8743 (39), 9182
Cost of construction, 8908 (11), 8933, 8967.
Dimensions of, 9937.
Ovens with gases utilised for heating—
Water evaporated per lb. of coal carbonised, 9634 (6).
Yield of coke per ton of coal, 9634 (7).
Ovens with gases not utilised for heating, advantages claimed for, 9634 (5).
Proportion of coke obtained from given quantity of coal, 8743 (41) 8778.
Quantity of coal required to produce 1000 tons of coke, 8908 (11).
Underflue ovens, details concerning, 9184 (6a).

COKING PLANT—*cont.*

Beehive Ovens—*cont.*
Wastefulness of, 8908 (11) 8935.
Waste gases utilised for heating, 8743 (40), 8763.
Without flue ovens, details concerning, 9184 (6a).
Working, details of, 8908 (11), 9740 (3).
Bye-product recovery ovens—
Bauer Ovens—
Charge, size of, 9241.
Details concerning, 9184 (6a)
Scotland, used in, 8774.
Coal of certain quality requires peculiar shaped oven and treatment, 8908 (14).
Coke from, prejudice against, dying out, 9634 (10).
Common slack and Durham Coal mixed produce good coke, 15662.
Coppée Ovens—
Details concerning, 9184 (6a).
Principle on which worked, 9634 (8).
Rapid coking by, advantages of, 9634 (8).
Scotland, used in, 8774.
Yield of coke per ton of coal compared with that from Beehive ovens, 9634 (8).
Cost of construction, 8743 (64), 8908 (22), 9281, 9666.
Economy—
Resulting from use of, 9369 (13).
Which would follow entire replacement of Beehive ovens by, 9369 (23), 9383.
Financial results of operating compared with Beehive oven, 8966.
Kopper's Regenerative Ovens—
Coke produced in, compared with Beehive coke, 10131.
Efficiency of gas produced, 10081.
Full economy gained by power produced in gas engines and turned into electricity, 10118.
Weardale Colliery, installation at, 10125.
Kopper's Retort Ovens—
Bye-products, method of extracting and refining, 10143.
Charge, length of, 10140.
Cost of 100 oven installations, 10158.
Details concerning, 10081.
Gas—
For lighting and power production, method of producing, 10141.
Illuminating power of, produced in 10137.
Linings, countries supplying, 8908 (25).
Number of, in this country formerly small, 15708.
Oil fuel, quantity of, which could be added to the oil resources of the country by extended use of, 15077.
Otto-Hilgenstock Ovens—
Advantages claimed for, 11234, 11237.
Details concerning, 9293, 9335.
Durham manufacturers using, 11233.
Production of coke by, annually, 9036.
Retort Ovens—
Advantages obtained by use of, 11217.
Annual gain to Great Britain possible by general use of, 9636 (1) 9680.
Linings, clay for, where obtained, 8908 (25) 8985.
Saving to be effected by replacing Beehive with, 10083.
Saving in coal by use of, 9142.
Semet-Solvay Ovens—
Analysis of coal and coke, 8743 (53).
Coke, sizes into which separated, 8743 (46)
Economy of, 8902.
Process of coking and bye-product recovery, described, 8743 (45).
Product from, result of test experiments, 10315.
Proportion of coke obtained from given quantity of coal, 8743 (55) 8778, 10263.
Thousand tons per week, number of ovens required to produce, 9089.
Simon-Carvès Ovens—
Details concerning, 9184 (6c).
Inventor of, 9634 (10).

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COKING PLANT—*cont.*
- Bye-product recovery ovens—*cont.*
  - Simon-Carvès Ovens—*cont.*
    - Makers' arrangements concerning purchase of slack, 9943, 9951.
    - Points in which differing from Kopper's ovens, 10128.
    - Principle of construction compared with Coppée & Otto-Hilgenstock ovens, 9335.
    - Production of coke compared with that of Beehive ovens, 9254, per 100 tons of coal, 10263.
    - Repairs, cost of, 9313.
  - Surplus gas—
    - American storage of, 9167.
    - Uses for, 9150, 9163, 9179, 9206, 9634, (11) 11240.
    - Value of in h.p., 9148, 9159.
  - Types of, details concerning, 9184 (6c).
  - Union of collieries in erecting large plant suggested, 10360.
  - Value, nett, of bye-products per 1000 tons of coke, 8908 (23).
  - Width of oven varying with quality of coal, 9634 (11).
  - Working, details of, 8908 (11, 20).
  - Yield of coke from compared with that from Beehive ovens, 9634 (12).
- Central establishment drawing coals from several collieries, advantages of, 9718.
- Coke ovens built in series back to back, result of experiments with, 11210, 11211.
- Continental Collieries driving whole plant by power derived from coking installation without boilers, 10113.
- Drawing coke, loss in, 9302, 9733.
- Hundred oven installation—
  - Gas engines connected with, 10174.
  - Horse power produced by, 10172.
- Minimum size of installation for profitable working, 9002.
- Monmouthshire Coalfield, type of oven used, 10257.
- Non-recovery ovens—
  - Loss per week on each 1,000 tons of coke manufactured, 8908 (11).
  - Quantity of coals used to produce 1,000 tons of coke, 8908 (11).
  - Use undesirable, 11208.
  - Working, details of, 9808 (11).
  - Yield of coke compared with bye-product recovery ovens, 9055.
- Ovens—
  - Linings, small foreign bricks used for, 8825, 9062.
  - Pearson & Knowles' Collieries, cost of plant, 9743.
  - Repairs to, 8743 (52) 8825, 8908 (24) 9098, 9213.
  - Scotland, types of oven used, 8743 (38) 8774.
  - Thermal comparison of various types, 11219.
  - Type, choice of depends on quality of coal, 9034, 9223.
  - Types of, 8909 (11).
  - Undrawn, loss occasioned if left, 9733.
- South Wales, recovery ovens not used, 10249.
- Steam boilers (Lancashire type)—
  - Number of coke ovens required per boiler, 9184 (6b).
  - Types of, details concerning, 9184 (6b).
- Surplus gases, steam raising efficiency per ton of coal coked, 10089.
- Waste—
  - Gases from ovens, mode of utilising, 9206.
  - Heat from burnt gas used for steam raising, 11241.
- Working—
  - Method of, 9730.
  - On large scale, drawing coal from many collieries to one plant, economy of, 8801.

COLLIERIES—
- Abram—
  - Coal—
    - Except locomotive all sent in own wagons, 12114.
    - Sent to Liverpool for shipment, 12096.
  - Wagons—
    - Delay in return of, financial loss caused by, 12153.
    - Size of, 12181.

COLLIERIES—*cont.*
- Ashton Moss, temperature of strata, 9906, 15566.*
- Astley Pit, Dukinfield, temperature of strata, 15566*.
- Boilers, types used at, 9249, 12778, 14721.
- Boldon, temperature of strata, 15566 (11).
- Bothwell Castle—
  - Coal and coke, analyses of, 8743 (30) (44).
  - Coke—
    - Markets for, 8743 (54).
    - Prices realised for, 8743 (54).
  - Coking plant, 8743 (35) 8906.
    - Beehive ovens, waste gases from, saving effected by use of, 8743 (40).
  - Dirt—
    - In coal, troubles concerning, 8743 (31).
    - Proportion per hutch of coal, 8743 (31) 8758.
    - Removed from coal, proportion of total output, 8758.
  - Ell Seam, system of working, 8743 (30).
  - Export, amount of, 8871.
  - Large and small coal, proportions obtained with 1¼ to 2 inch mesh screens, 8753.
  - Output—
    - Division of, December, 1902, 8743 (30).
    - Tons per month, proportion of dirt separated from, 8743 (31).
  - Prices realised, 8743 (33).
  - Product of, markets for and selling prices, 8743 (30).
- Bredbury, temperature of strata, 15566.*
- Capel Ifan, Gwendreath Seam, thickness, 16215 (10).
- Capital costs increase at a greater ratio than the depth of sinking, 11026.
- Crosshands, Triquart Seam, thickness, 16215 (11).
- Dalton Main, sinking through magnesian limestone, 15520.
- Denaby, washing plant in use, 10713.
- Denton, temperature of strata, 15566.*
- Depth of sinking will in the future necessitate larger capital and larger area of working, 15014.
- Dungannon, slack, percentage of incombustible, 15255.
- Financial management of, 11011.
- Fowler's, Pontypridd, temperature of strata, 15566.*
- Gorseinon—
  - Bituminous steam coal, proportion of volatile hydrocarbons contained in, 15735.
  - Steam coal "dry," proportion of volatile hydrocarbons contained in, 15735.
- Gwauncaegurwen, depth of shaft, 16043.
- Gwendraeth, Carway Seam, thickness, 16215 (2).
- Haulage—
  - Electricity generated by gas engines used for, 16580.
  - Mechanical replacing horses, 14981.
- Hoyland Silkstone, large coal, proportion of, 9922.
- Kilsyth—
  - Anthracite—
    - Analysis of, 8743 (69).
    - Sizes separated into, 8743 (68).
  - Markets for various sizes of coal, with prices realised, 8743 (70).
  - Varieties of coal met with, 8743 (34).
- Lidgett, thickness of seams got by machine, 10765.
- Mitchell's Main, washing plant in use, 10713.
- Modern appliances—
  - Conditions under which putting in is economically possible, 14912.
  - Effect on coal consumption, 14915.
- Modern plant, economy of fuel compared with twenty-five years ago, 14710 (lh).
- Monkwearmouth, temperature of strata, 15566.*
- New Moss—
  - Black Mine, depth of, 9784 (3).
  - Depth and thickness of, 9784 (3).
- Nook Pit, temperature of strata, 15566.*
- Opening out, circumstances deterring men from, 10984.
- Park Mill and Emley Moor—
  - Coal-cutting machines—
    - Method of working, 17035.
    - Types used, 17025, 17028, 17047, 17054.
  - Coal got by machine, method of dealing with, 17175.

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COLLIERIES—*cont.*
Park Mill and Emley Moor—*cont.*
Cost per ton of machine cutting, including fuel and maintenance, 17202.
Division of labour, 17164.
Electric cables, difficulties with, 17129.
Filling, method practised, 17126.
Holing, mode of, 17034, 17074.
Inclination of seams, 17086.
Length of face cut by machines in eight hour shift, 17039.
New Hards Seam—
Headings, cost of driving by machines and hand labour compared, 17055.
Large coal got from headings by machine and hand labour compared, 17072.
Quality of coal, 17096.
Small coal got from headings by hand and machine labour compared, 17072.
Strata above, nature of, 17095.
Thickness, 17073, 17094.
Types of machine used in, 17094.
Output—
Hand labour, proportion got per man per shift by, 17224.
Machine compared with hand—
Proportions got in 1902, 17019.
per day, 17022.
per man, 17094.
Saving by machine, 17216.
Roads, distance between, 17125.
Seams, depth from surface, 17086.
System of working practised, 17024.
Wheatley Lime seam—
Large coal got from heading by hand and machine labour compared, 17071.
Output, tons per man per shift, 17222.
Quality of coal, 17096.
Small coal got from heading by machine and hand labour compared, 17071.
Strata above, nature of, 17095.
Thickness, 17073, 17086.
Pearson & Knowles Coal and Iron Company, annual output, 9740 (1).
Pease and Partners—
Coal, preparation for coking, mode of, 9186.
Coking plant, capacity of production per annum, 9184 (3).
Loss of coal in washing, 9327.
Washing plant, types used, 9184 (5).
Plant, economy effected in during last twenty-five years, 14822.
Pochin Pit, electric plant used, 15038.
Pontyberem—
Big seam, thickness, 16215 (3).
Breslyd or charcoal seam, thickness, 16215 (9).
Crasucha seam, thickness, 16215 (7).
Crasissa seam, unproved, 16215 (8).
Ddugaled seam, thickness, 16215 (5).
Faults and disturbances, 16215 (15).
Green Seam, section and thickness, 16215 (4).
Little Seam, thickness, 16215 (12).
Lower Pumpquart Seam, thickness, 16215 (13).
Rhasfach Seam, thickness, 16215 (14).
Stanllyd or Big Seam, thickness, 16215 (6).
Powell-Duffryn—
Railway—
Details concerning, 11970.
Wagons, number owned by, 11918.
Radstock, temperature of strata, 15566.*
Rosebridge, temperature of strata, 15566.*
Rothervale, washing plant in use, 10713.
Roundwood—
Depth of new pits, 15443.
Varieties of coal sent out, 15412.
Sherwood, shaft sinking, new appliance used for, 10954, 10962.
South Hetton—
Boring, Section of, 15567.
Strata temperature, 15566 (11).
Staveley Iron and Coal Company, washing plant in use, 10713.
Tredegar, electrical plant, details concerning, 15001.
COLLIERIES—*cont.*
Wagons—
Collieries should own all used, 11291.
Difficulty of weighing, with large wheel base, 12009.
Screens, difficulties with regard to, 11529 (4), 11671.
Size—
Best suited to requirements, 15374.
Increasing, alterations rendered necessary at pit's mouth, 15374, 15383.
Weighing machines, Alterations in, to permit of dealing with 20 to 40 ton wagons possible at small cost, 11678.
Wharncliffe-Silkstone—
Coking coal only washed, 10712.
Holing, method of, 10907.
Inclination of seams, 10908.
Output, cost of production compared with selling price, 10820.
Whitehaven, temperature of strata, 15566 (11).
Winding engines—
Difficulty of designing economical, 12779.
Economy effected by introduction of expansion, 12788.
Method of working, 12781.
Proportion of coal consumed to weight lifted, 12789.
Worked out colliery, method of utilising plant and opening out new seams when partly, 15424.
COLLIERY CONSUMPTION OF COAL—
Average annual, 14835, 15597 (14).
Haulage, length of, affecting, 14841.
Percentage of, 9784 (26).
Saving possible by introduction of most modern appliances, 14830.
South Wales Coalfield, Western Division, 15783, 16067, 16107, 16175.
Wastefulness of engines, 12776, 12826.
Wharncliffe Silkstone Collieries, annual consumption, means of diminishing suggested, 10788.
COLLIERY OWNERS—
Difficulties with, 10976.
Trespasses by, 16128.
COLOMBIA, Petroleum production, 13353 (57).
COLQUHOUN, MR. WILLIAM, A.M.I.C.E.
Evidence on economies in preparing coal for sale or use: particularly on the manufacture of briquettes, 9989–10065.
COMMERCIAL GAS COMPANY (*see* Gas Companies.)
COMPRESSED COAL—
Coke made from—
Advantages gained in using, 9638, 10096, 10101, 10132.
Qualities of, 8908 (12), 8951.
Compressing process, details concerning, 9306.
Inferior coal so treated produces good coke, 9113.
Labour saved by use of in coking, 9088.
Ovens hold larger charge of compressed coal than in natural state, 9112.
Repair to ovens, cost reduced by using, 9098.
CONDENSATION—
Heat loss in steam engines caused by, 16364.
Superheaters prevent, 16364.
CONDENSERS—
Central, at colliery, advantages of, 14792.
Incrustation of boilers prevented by, fuel consumption diminished in consequence, 16651.
Temperature of water coming from, 14738.
CONDENSING—
Economy of—
Compound engines increased by, 14710 (1d).
Dependent on cost of coal and quality of boiler water, 14790.
Water, proportion required to weight of steam to be condensed, 14949.
COOKING BY GAS (*see* Gas.)
COOLING TOWERS, Cost of construction per i.h.p., 15049.
COTTON INDUSTRY, Indian, standard of economy for engines defined, 16353.
CROSSLEY, MR. W. J.
Evidence on the production of power by gas engines, 12864–12944.

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CROWBOROUGH, Sussex, Natural Gasfields of England, Limited, making experimental borings at, 11307.

CRUSH—
Increases with depth of mine, 11042.
Large coal, proportion of affected by, at great depths, 9784 (43.)
Loss of coal by, in Pillar Stall System, 15765.
Ratio of increase in relation to depth, 9784 (42).
Roof—
Full of gas gives much trouble with crush, 10869.
Quality of influencing, 10868.

CRYSTAL PALACE GAS COMPANY (*see* Gas Companies).

CULM, Anthracite small coal so called, 15741.

CYCLONE COMPANY for dust firing, Reference made to, 10842.

DANT, washing, method of, 9766.

DARBY, MR. JOHN H.
Evidence on economies in preparing coal for sale and use; more particularly coking, 8908–9183.

DARTMOOR, Peat bogs of large extent on, 16834.

DAVIES, MR. MORGAN WILLIAMS, A.M.I.C.E.
Evidence on waste in working in the anthracite coalfield of South Wales, 16040–16141.

DEACON, MR. MAURICE, M.I.C.E.
Evidence on economies in the use of coal in the production of power, 14710–15055.

DEEP MINES—
Air temperature cooled by exhaust air from coal-cutting machines, 11205.
Commercial value of, 9784 (46).
Development of coal trade influenced by depth, 10970.
Temperature the main obstacle to working at great depths, 11038.
Working, method of, 9793.

DELLWIK GENERATOR—
Accidents with, safeguards against, 9403.
Coke, quality used in, 9369 (24) 9560.
Efficiency of, 9369 (24).

DELLWIK, MR. CARL.
Evidence on the manufacture of water gas, 12945–13067.

DEPRECIATION OF STEAM BOILERS (Belleville) compared with gas producers, 13180, 13236.

DEPTH, Limit of—
Cost and maintenance of winding plant the only consideration, 9784 (41) 9792.
Greatest depth of working practicable, 9793, 9821, 10818.
Strata—
Nature of, influences, 10870.
Temperature of, variation of ratio in relation to depth from surface, 6784 (36).

DETERIORATION OF COAL—
Crush a principal cause of, in pillar and stall system, proportion of loss by, 16159.
Tropical climates, more rapid in, 12529.
Welsh coal, period during which it remains in good condition, 12326.

DIRT, increase in proportion sent up with coal, 9855.

DIRT BANDS, miners paid for removing, from lumps of coal, 10748.

DISAGREEMENTS of owners, lessees etc., in South Wales Coalfield, Western Division, workmen in large numbers thrown out of employment through, 15762.

DISEASE, caused by high temperature in mines (*see* Germany, Westphalian Mines, and Dolcoath Mine).

DOCKS—
Garston—
Increased accommodation required to cope with coal trade, 12081.
London and North Western Railway Company building new dock, 12084, 12178.
Shipping trade increased by effect of group rates charged by London and North Western Railway Company, 12088.

DOCKS—*cont.*
Grimsby—
Accommodation inadequate, 15346.
Liverpool—
Coaling dock required, 12168.
Cranes, lifting power of largest, 12138.
South Wales, hoists capable of lifting 20 tons gross weight, 12064.

DOCK SCREENINGS (*see* Royal Navy, Coal Supply).

DOLCOATH MINE—
Disease among men caused by high temperature, report on by Dr. Haldane, 10703.

DOMESTIC CONSUMPTION OF COAL—
Economies suggested, 9430 (8), 9537, 9576, 13259.
Quantity in ordinary home, 16627.
Smoke-producing grates, legislative pressure would do away with, 9430 (8).
United Kingdom, annual, 9369 (2).

DOWSON GAS, (*see* Gas).

DRAINAGE—
Old workings supposed to contain water should be officially inspected before drainage is commenced, 15789.
South Wales Coalfield, Western Division, Statutory measures on lines of South Staffordshire Drainage Commission suggested, 15762, 15971.

DRAUGHT—
Forced hot air, systems used in conjunction with air-heaters, 12797 (1).
Heat loss resulting from admission of too little air, 16475.
Mechanical, economy resulting from, 16484.
Regulating on locomotives, method of, 16486.

DRAUGHT PRODUCERS, Howden's system, principle of, 12846.

DROSS, term defined, 8754.

DUFF—
Calorific value in power production, 16191.
Method of using in furnace, 16194.
Price realised by, 15876, 16193.
Purity of, 93634 (3), 9699.
Small portion used in briquette manufacture, 16182.

DUFF GAS (*see* Gas).

DUSSELDORF EXHIBITION, German exhibition of blast furnace engines, 14505.

EASTBOURNE, coal consumption per annum for gas-making purposes, 11348.

EASTERN ARCHIPELAGO, petroleum production, 13350 (23)

ECONOMIES in the use of coal —
Capital, effect of large, 14715.
Difficulties in the way of adopting, 9430 (3).
General within the last twenty years in all industries employing power, 15687.
Means of, suggested, 9430 (2) 10113, 14740, 14800, 15264.
Production of power at Wharncliffe-Silkstone Collieries, economy resulting from introduction of Mond producers with recovery of ammonia, 10788.
Public instruction in methods of economising fuel necessary, 9581.
Washing and sorting enable better use of inferior coal, 14713.
(*See also* Central Heating of Buildings, Coking Plant, Electric Motors, Electric Plant, Gas, Incandescent Mantles, Kitson Light, Oil Engines, Oil Fuel, Peat, Solidified Petroleum, Steam Engines, Railway Carriage of Coal.)

ECONOMISERS—
Humidity in waste gases limits saving affected by, 12791 (2).
Use of, with high pressure boilers becomes more necessary as pressure is increased, 12835.

ECUADOR, Petroliferous territory undeveloped, 13353 (58).

EDINBURGH—
Temperature of strata at small depth from surface, 15566 (8).
Compared with London, 15583.

EDUCATION, improved standard noticeable among miners attending lectures at Cardiff University and County Council centres, 15789.

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EELES, Mr. John Procter, Colliery Sales Agent—
Evidence on economies in preparing coal for sale and use; particularly as to the manufacture of coke, 10175–10494.

"Efficiency" of heat engine, term defined, 9369 (5).

Egypt—
Market for Welsh small coal, 12057.
Petroleum wells at Gebel-Zeit, 13353 (47) 13482.

Electrical drying of peat, process described, 16923.

Electricity—
Coal-cutting machines, danger prevents use of, as motive power for, 9987, 10891.
Cost of—
Fuel per horse power hour, 12864.
Fuel per unit sold, 9430 (1).
Producing B.T.U. with Korting 500 h.p. gas engine, using producer gas from Lancashire coal, with recovery of ammonia, 13151, 13218.
Distribution—
Compared as to economy with Mond gas, 9563.
Loss in, 16540, 16549.
Economy of, as motive power for coal-cutting machines compared with compressed air at pressure of 50–55 lbs., 17081.
Pressure of three phase currents regulated according to size of district, 10577.
South Russia, Ekaterinovska Company employ as winding power, 10786.
Storage of, 10536, 14875.
Winding engine exhibited at Düsseldorf, 10846, 10858.

Electric Light—
Bermondsey Street lighting, method of, 12620.
Coal consumption—
In gas engine and steam engine driven stations compared as to cost per unit of electricity, 16397.
Per h.p. hour, 14698.
Per unit sold, 14665.
Cost compared with gas, 12618.

Electric Lighting Stations—
Coal—
Consumption increased by variations in load factor, 14700.
Cost per unit, 14704.
Current price per unit, 14702.
Supplying houses with hot water for heating purposes by means of exhaust steam from engines, 16651.

Electric Motors—
Advantages of, compared with gas engines, 13129.
Continuous current, cost per h.p. compared with small gas engines using producer gas, 13129.
Supplied from lighting stations, coal consumption per h.p. and per unit, 14653, 14662.
Three phase, cost per h.p. compared with small gas engines using producer gas, 13129.

Electric Plant—
Saving in use of gas driven, when standing compared with steam driven, 13148.
Steam consumed per i.h.p. compared with compressed air plant, 14710 (1g).

Electric Power—
Advantages of, in collieries, 10890, 13142, 14710 (1g).
Air compressed by, for use in fiery pits, 14993.
Barcelona tramways, consumption of anthracite coal per kilowatt hour, with gas engines using producer gas, 13095.
Coal consumption—
Chemical works, 13079.
Full load test run, compared with that for 25 per cent. of load factor, and with gas engines and steam boilers, 13097.
Various qualities of coal compared per B.T.U. in steam and gas engine driven plants, 13074, 13094, 13224.
Collieries—
Development in, 14739.
Greatest economy obtainable by extended use of, 14800.
Haulage, can be used even in fiery mines for, 14801.

Electric Power—*cont.*
Companies, authorised capital, 13069.
Compressed air, hydraulic and rope transmission superseded by, 14710 (1).
Cost of production per B.T.U. per annum, 9431.
Danger from sparking, conditions leading to, 10904.
Distribution—
Cost of transmission from steam and gas engine driven Central Stations compared, 13119.
Small consumers benefitting largely by, 9425.
Economy in coal possible by generating power for distribution in bulk to large and small users, 16391 (2f) 16535.
English competition with French and Canadian electro-chemical firms, circumstances influencing, 14178.
Gas engines—
Saving resulting from use of, with producer gas for driving dynamos, compared with steam power, 13129.
Horse power, price per, 14161, 14171.
Lighting stations, improvement in load factor in, by increased use of power, economy resulting, 14460.
Rolling mills, variation of load renders cost of employing in prohibitory, 14902.
Stations, suggested installation on Irish peat bogs, 16804.
Three phase current with switches and fuses placed in oil baths, safety in use with coal-cutting machines compared with continuous current, 14996.
Transmission of, compared with producer gas, 14185.
Water power, current generated by, Niagara charges per h.p. compared with those in Canada and the French Alps, 14175.
Wharncliffe-Silkstone Colliery—
Cables, method of putting in, 10892.
Coal-cutting machines worked by, 10887.

Electrolytic Alklai Company, Electric power used by without intermission, 13210.

Engines (*see* Gas Engines, Oil Engines, Steam Engines).

Estate or Municipal Heating, Electric Lighting station supplying houses with hot water for heating purposes by means of exhaust steam from engines, 16651.

Ethylene, Illuminant of coal gas, 11453.

EVERETT, Prof., J.D., F.R.S., Secretary of the Underground Temperature Committee of the British Association.
Evidence on underground temperatures, 15566, 5593.

Explosions of gas from stored coal—
Cause of, 14263.
Not necessarily connected with spontaneous firing, 14148.

Export of Coal—
Restricting, probable result to coal trade, 11133, 11140.
United Kingdom, Annual, 9369 (2).

Factories—
Coal consumption—
Annual, 9369 (2), 15597 (14).
Reducing, means suggested for, 9430 (5).
Quality of coal used in 1903 compared with that used twenty-five years ago, 12824.

Fans—
Economy of, as draught producers compared with chimneys, 12843.
Waste gases, fan necessary to produce draught when heat is extracted by means of economiser and air-heater, 12842.

Feed-water (*see* Boilers).

Firebricks—
Dinas bricks, qualities of, 13743.
Glenboig—
Company use gas firing in manufacture of, 9369 (15), 9385, 9557.
Bricks used in Russia on locomotives, 13743.
Pease and Partners.
Constituents of experimental bricks made by, 9219.
Export of, 9319.
Soda and potash, heat affecting bricks containing, 9220.
Stourbridge, Great Eastern Railway using, 13843.

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FIRE GRATES, domestic grates giving most heat burn least coal and emit least smoke, 13259. (*See* Domestic Consumption of Coal,)

FIRING OF SEAMS, South Wales Coalfield, Western Division, spontaneous combustion caused large areas of steam coal to be shut down, 15762.

FISHER, MR. E. R.—
Evidence on waste in working in the South Wales Anthracite Coalfield, 16142, 16213.

FISH GLUE, Petroleum solidified by means of, 13342 (12).

FLASH point for oil—
California, standard of, 13345 (15).
Lamp oil, standard, 14258.
Limitation, importance of, 13345 (15).
Russian railways, minimum standard, 13345 (15).
Safety on ships cannot be secured by high flash point, 13449.
Standard—
Necessity for fixing, 13345 (15).
Raising, reduces quantity of petroleum obtainable from crude oil, 13585.
Varieties of oil fuel used on Great Eastern Railway, flash points of, 13853.

FOREIGN COAL, British steam users in the East and in Spain employ native fuel in preference to importing English coal, 15156.

FORGIE, MR. JAMES TENNANT—
Evidence on economies in the preparation of coal for sale and use, 8740, 8907.

FORMOSA, Petroleum found in small quantities, 13353 (64)[4]

FRANCE—
Anzin Colliery, temperature of strata, 15566*.
Shale oil industry, 13353 (52).

FURNACE OIL, Great Eastern Railway burn, on locomotives, 13864.

FURNACES—
Closed top type, economy of, 14710 (2).
Forced draught, coke dust used in, 14710 (1c).
Meldrum type—
Firms using, 15181, 15199, 15212, 15215, 15219, 15225, 15228, 15237, 15251, 15257, 15263, 15295.
Fuel usable in, 15206, 15228, 15237.
Principle of, 15203.
Refuse accumulations utilised in, 15209, 15218.
Meldrum and Schwartzkopff types compared, 15272, 15278.
Siemen's regenerating furnace, fuel used in, 14710 (2),
Temperature, high, conditions necessary for attaining 12805 (2).

GALICIA, Petroleum wells at Boryslaw, 13350 (22).

GARDEN CITIES, Central heating installation particularly suitable for, 16665.

GAS—
Acetylene, Progress made by, 12709.
Analyses should be constantly made at power stations etc., to prevent loss, 16482.
Blast Furnace gas—
Advantages of compared with hydrogen, 14492.
Analysis of, 14492.
Carbon-monoxide in, percentage, 14514.
Cleveland furnaces, annual waste of, loss of coal represented by, 14588.
Direct use in gas engines, economy of, 9380, 14636, 14710 (2), 14957.
Dust must be removed before using in engine, 13182.
Economy effected by closed top furnaces, 14854.
Electric energy for railway traction may be generated by, 14590.
Frodingham furnaces, proportion of carbon-monoxide contained in gas from, 14495.
Oxygen, proportion used with, in "Static" system, 14515.
Poverty of, preventing ignition overcome by "Static" system, 14502.
Preparatory treatment of, invented by Mr. B. H. Thwaite, tested at Glasgow Iron Company's works, 14492.

GAS—*cont.*
Blast Furnace Gas—*cont.*
Proportion employed in heating stoves, 14856.
Purifying, mode of, 14710 (2).
Relative production of power when burnt under steam boilers and in gas engines, 12864.
Sheepbridge Iron Works, Gas purifying plant, details concerning, 14883.
Supply for outside use unreliable unless from very large plants, 14871, 14877.
Theoretical quantity of, obtainable from Derbyshire blast furnace with certain output of iron per week, 14870.
Thermal—
Assets, expenditure exemplified, 14588.
Value in B. T. U., 14500.
Thwaite or "Static" System—
Advantages claimed for, 14519.
Annual saving in—
Coal by using, 14588.
Money by using, 14590.
Cost of installation of plant making 100 tons of iron daily, 14603.
Economy of using purified gas in internal combustion engines compared with burning it under boilers for steam raising, 14636.
Installation of pioneer plant near Essen, Germany, 14495.
Method described, 14544.
Objects of, 14498.
Plant, durability of, 14505.
Power can be supplied within certain radius, 14591.
Pressure, method of, 14503.
Proportion of oxygen used with gas, 14516.
Safety of—
Compared with blast furnace steam boilers, 14505.
Gas purified by, 14612.
Uniform calorific value enables gas engines to drive alternating electrical generators 14571.
Utilising for production of power, method of procedure suggested, 14598.
Waste, use of, under boilers, loss of heat compared with direct use in gas engines, 14710 (2).
Blue Water Gas—
Candle power obtainable from under certain conditions, 14215.
Carbon monoxide contained in, percentage of, 14211 (6).
Cost per 1,000 feet in holder (Dellwik process), compared with coal gas, 14222.
Cubic feet per ton of coke produced by Dellwik process, 14240.
Economy in use as enricher compared with carburetted water gas, 14356.
Enrichment with oil preferable to benzol for illuminating purposes, 13051.
Illuminating power with incandescent mantles compared with coal gas, 14214, 14275.
Mixing with coal gas, effect on illuminating power, 12946.
Process of manufacture, 14233.
Quantity obtainable from one ton of coke, 14342
Unenriched water gas, 12946.
Boilers, heating with waste gases from coke ovens, saving in fuel consequent on, 9741, 9758.
Burners—
Flat flame, advantage of adapting to quality of gas supplied, 12736.
Kinds generally used unfitted to give good results, 14322.
Carburetted Water Gas—
Addition to coal gas—
Best and cheapest method of effecting, 14238, 14310, 14340.
Effect of, 14329.
Makes no difference in cost to customer, 12566.
Object of, 12558.
Annual production, 12559.
Burner for coal gas can also be used for, 14279.

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GAS—*cont.*

Carburetted Water Gas—*cont.*

Carbon monoxide contained in, percentage, 14210 (6).
Coal annually saved by use of, 12579, 12582.
Coke—
Price enhanced by use of, 12592.
Quantity—
Annually used in making, 12582.
Required to make 1,000,000 cubic feet of gas, 12595, 12719.
Dellwik process of manufacture, 12741.
Demand for coal gas reduced by use of, 12588.
Gas Light and Coke Company supply gas containing 20 per cent. of, 12565.
Percentage used to enrich coal gas, 12711, 14210, (5) 14236.
Poisonous properties of, 14225.
Processes used in manufacture of, 12557, 12741, 14233.
Proportion used to enrich coal gas supplied by London Gas Companies north of the Thames, 14228.
Solar Oil mixed with, method employed, 12740.
South Metropolitan Gas Company does not use, 12565.
Tottenham and Edmonton Gas Company supply to customers coal gas containing 50 per cent. of, 12563.
United States, percentage of, to total gas manufactured, 12496.

Coal or illuminating gas—
Annual—
Production, 12559.
Quantity of coal used in manufacture, 12578.
Calorific power, 12648, 12733.
Candle power—
Introduction of incandescent mantle tending to reduce, 13054, 14210 (1).
Loss in transmission—
Greatest in gas enriched with carburetted water gas, 14294.
Proportion per mile, 14283.
Coal carbonised in 1902 for production of, 14210 (3).
Compressed gas, greater light obtained from, 12744.
Compressing for general use, difficulties in the way of, 12747.
Compressors used by South Metropolitan Gas Company, 12745.
Consumption of coal in manufacture in 1882 and 1901 compared, 12599.
Consumption reduced by use of Welsbach mantles, 12624.
Cooking by—
Cost compared with close coal range, 16628.
Economy of fuel which would result from general adoption of, 16627.
Cost of production per 1,000 cubic feet, 12947, 12988, 13038.
Enrichment—
Useless, 12669.
With carburetted water gas—
Coal saved by, 14210 (4).
Cost compared with that by cannel gas, 14212.
Formerly entirely by cannel coal gas, 14212.
Illuminant, constituents of, 11455.
Low candle power—
Advantages of sending out, 14319.
Better light given with Welsbach mantles than with higher candle power, 12724.
Most economical method of making, 14210 (6), 14238.
Minimum useful illuminating point, 14213, 14354.
Necessity for production has disappeared owing to introduction of water gas and Welsbach mantles, 2660.
Petroleum in conjunction with water gas used in manufacture, 13342 (8).
Poor quality, difficulty of making, 12661.
Price per 1,000 feet at works, 16417.
Producing mode of, 10495 (2).
Quantity obtainable from one ton of coal, 14342.

GAS—*cont.*

Coal or illuminating gas—*cont.*

Reduction of—
Candle power accompanied reduction in price authorised by Act of Parliament, 12671.
Price increases consumption, especially as to heating and production of power, 12652.
Price to consumers of power unfair to consumers of light, 12742.
Tendency of consumers to require increased light, 14332.
Thermal value, 9369 (10).
Transmission in mains causing loss of candle power, 14282.
Coke Oven gas, not so suitable as purified blast furnace gas for electrical driving, 14644.
Cooking, use of gas for, largely extending, 12644.
Dowson Gas—
Analysis of, 12913.
High candle power produced by burning with incandescent mantle and special burner, 14272.
Thermal value, 9369 (10).
Duff Gas, gas engines worked with, 9369 (11).
Economy possible by substitution for coal in production of heat for industrial purposes, 13124.
Germany, percentage of heat value in coal used, 11245.
Heating, use of gas extending for, 12644.
Illuminating power—
Of coal gas mixed with carburetted water gas raised or lowered according to quantity of petroleum used, 12564.
Tendency to lower, 13054.
Ingredients of manufacture prior to 1890, 12553.
Manufacturing near coal pits for transmission to London impracticable on account of cost, 12649.
Marsh gas, effect of mixing oxygen with, before burning in gas cylinder, 14581.
Mond Gas—
Ammonia sulphate recovered per ton of slack, value of, 10495 (6).
Analysis of, 12913, 12928.
Automatic carbonic acid recorder, results obtained, 15100, 15126.
Calorific value of, 10495 (5) 12648.
Carbonic acid, percentage contained in flue gas, 15099.
Coal, class of, used in making, 10495 (4) 16401.
Coke oven gas, richness of, compared with, 10145.
Competition with coal gas for power and heat production will be most felt in manufacturing centres, 12648.
Composition of, 10495 (4).
Cubic feet per ton of slack, 10495 (5) 10649, 10673.
Evaporative power compared with coal firing and mechanical stoking, 15095.
Heating power compared with that of coal, 10495 (5), 10653.
Loss in distribution compared with electric current, 16549.
Method of applying to Babcock boiler at Runcorn, 15133.
Purifying, advantage of, 15113.
Small coal consumption, economy realised by, 9414.
Steel works, economy from use of in place of coal, 15117.
Unsuitable for use as illuminating gas with Welsbach mantles, 12663.
Use of, in manufactories, effect on rates for carriage of coal, 11891.
Mond and Dowson gases—
Compared, 12889.
Mixed for use by Messrs. Crossley Bros., 12909.
Mond and Duff gases compared, 9481.
Mond and Wilson gases compared, 14193.
Natural gas—
America, number of wells bored, 11298, (6).
Analyses of, 11434.
Bassingbourne, Cambridgeshire, 11283.

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Gas—*cont.*

Natural gas—*cont.*

Boreholes—
Cost of, 11425.
Hastings bed, sunk in, gas struck at several levels, 11271.
Small diameter, reason for, 11515.
Time occupied in putting down 400 feet, 11427.
Boring wells, method of, 13315.
Brighton and Eastbourne, Natural Gas-fields of England lay down mains for supply to, 11369.
Calorific value, 11298.
China gas-fields, situation of, 11298 (5).
Composition of, 11294, 11440.
Conditions under which gas may be looked for, 11282.
Distillation still proceeding in Kimmeridge and Oxford beds, 11403.
Efficiency as power producer compared with coal gas, 11295.
Evaporative power compared with coal, water and producer gases, 11298 (1).
Geological Society mention, in work on water supply in Sussex, 13352.
Heathfield gas, volume required to produce 1 b.h.p. in good gas engine compared with coal, water or producer gases, 11298 (2).
Houses supplied with, for lighting, heating, and cooking, 11291.
Pressure per square inch at, 11298 (5).
Source of supply, 13506.
Station lighted with, since 1898, 11268.
Surplus gas blown off daily, amount of, 11362.
Thickness of strata in which gas is found, 11385.
Well sunk 8 years ago yielding as well as at first, 11506.
Wells bored and being bored, 11298 (6).
Highest part of the anticlinal arch or lid over the natural gasholder, where situated, 11521.
Illuminating power—
Compared to Cannel coal gas, 11450.
Tests of, 11463.
Iron mills, changes in, caused by use of, 11267.
Origin of, 11372.
Oxford bed, yielding, 11371.
Pressure holder, size and method of construction, 11482.
Purity and efficiency of, 10690.
Russians use, in lime kilns at Surakhany, 13510.
Sussex, 11267.
Gasfield, area of, 11511.
Thermal value of, 11475.
Weymouth harbour, 11386.
(*See also* America).

Oil Gas—
Cost per 1,000 candle power with mantle, 14210 (7).
Used by Gas Companies to enrich poor gas made from inferior coal, 9369 (20).

Producer Gas—
Ammonia recovery essential to high financial efficiency of producer, 10496.
Bituminous slack, otherwise wasted, used in manufacture, 9378.
Boilers, firing by, not economical unless with recovery of ammonia, 10658.
Carbon monoxide, percentage contained in, 10495 (11).
Coal—
Inferior now left unworked, can be used in manufacture of, 10633.
Ordinary, use of, in manufacture causes difficulties with tar, 14687.
Used in place of coke in manufacture, 14196.
Cost of, compared with steam, 10589, 10592.
Direct use of, 9587, 12852.
Economy in use for power production, lighting and heat, as against the use of raw coal, 10495 (5, 11) 10613.

Gas—*cont.*

Gas Producer—*cont.*
Electrical current generated by—
40 per cent of total production so used. 10495 (9).
Uses to which applicable, 10495 (9).
Extended use of, arguments in favour of, 10495 (11).
Firms using, 10607.
Heating, proportion of total production estimated to be used for, 10495 (9) 10553. 10576.
Heat lost in converting fuel into gas, percentage of, 12864.
Inert constituents, percentage contained in, 12952.
Loss—
In transmission due to friction, 10459 (7).
Of heat in converting coal into gas compensated for in use of latter, 9443.
Manufacture—
On board ships feasible, 9455.
Principles of, 12805 (3).
Marsh gas produced by use of coal in manufacture, 14198.
Mond and Wilson gas, amount of steam required nearly equal, 14193.
Power production, consumption of slack per i.h.p. hour, 9369 (11).
Price—
At which gas can be profitably transmitted, conditions influencing, 14188.
At which gas could be profitably supplied to large and small consumers, 10628.
Of slack used in manufacture, 12864.
Producer plant, indispensable qualities of, 10496.
Production, mode of, 10495 (2).
Purposes for which suitable, 10495 (3, 11).
Small factory, anthracite producer most suitable for, 10637.
Smoke, absence of, during manufacture and use, 10495 (11), 10609.
Source from which obtained, 9369 (10), 9377.
Storing, effect of, 9592, 10536, 10671.
Tar must be removed before using gas in gas engine, 13182.
Temperature—
Highest obtainable without regenerator, 10596.
Of producer affecting recovery of ammonia, 10496.
Thermal value in B.T.U., 14500.
Transmission of—
Economy of transmission in pipes compared with conversion into electric current, 10508, 10572.
Price would regulate demand, 14187.
Size of mains a difficulty, 10495 (7).
Purifying, systems of, 9369 (25).
Rate of increase in consumption, falling off in, since introduction of cheap mineral oils, 12643.
Siemen's gas, mode of producing, 10495 (2).
Slot meters, number annually used by customers of South Metropolitan Gas Company, 12605.
Tar oil, production in this country cheaper than importing, 15088.
Transmission in pipes—
Cost—
Circumstances influencing, 12651.
Reduced by large pipes and low velocities, 10556.
Greatest distance to which as yet transmitted, 10643.
Limits of distance possible with one and with three sets of pumping, 10510.
Loss, percentage of, for compression on each 80 miles travelled, 10526.
Pressure and velocity giving maximum economy, 10561.
Pressure required for 80 miles, 10520.
Producer gas, economy of transmission and conversion into electrical energy at points where needed, compared with conversion at pit's mouth, 10572.

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GAS—*cont.*
- Transmission in pipes—*cont.*
  - South Staffordshire Mond Gas Company have Parliamentary powers to distribute gas in South Staffordshire, 10603.
- Turbines, construction of, advantages which would ensue, 9369 (8), 9453.
- Use of—
  - As producer of power, employment of gas engines only contemplated, 10579.
  - Would be largely extended if reduction of illuminating power were permitted, 12646.
- Waste gases used direct in blast gas engines in iron works and in engines for driving dynamos, 11899.
- Water Gas—
  - Advantages as against coal and producer gases, 12946.
  - Calorific power compared with producer and coal gases, 12946.
  - Carbon monoxide, percentage contained in, 13016.
  - Cheapness as fuel, condition influencing, 9369 (24), 9403, 9559.
  - Composition of, 12946.
  - Continental towns use as illuminating gas with mantles, 12991, 13015.
  - Cost of production per 1,000 cubic feet, 12948, 12988.
  - Crucible steel melting, economy of water gas compared with coke and electricity, 12959, 12961.
  - Cubic feet per ton of coal, 9369 (25).
  - Dellwik process of manufacture—
    - Advantages of, 13006.
    - Carbonic acid gas, percentage contained in, 13008.
    - Manufacture, principles of, 13007.
    - Valves, reversing, modifications in, 9492.
  - Distribution, cost compared with producer gas, 13062.
  - Economy—
    - In consumption of coal at gas works affected by mixing coal and water gas, 12946, 12970.
    - Resulting from high temperature of flame, 12955.
  - Gas Works having installations of, in this country, 12998.
  - Illuminating power of coal gas—
    - Mixed with 40 per cent. of blue water gas, 13049.
    - Used with mantle improved by mixture with water gas, 12965.
  - Labour saved by gas companies using, 12714.
  - Largest installations of plant in this country, 12999, 13002.
  - Odorised by makers, 13018.
  - Poisoning, cases of, at Leeds Forge Works, 13021.
  - Production, mode of, 10495 (2), 12946.
  - Purposes to which applicable, 12946.
  - Qualities permit distribution at less cost than coal and producer gases, 12946, 12951, 13062.
  - Successful use in large gas engines, conditions influencing, 9369 (25).
  - Thermal value, 9369 (24).
- Young & Beilby's gas, analysis of, 9485.

GAS COMPANIES—
- Board of Trade returns relate only to those supplying under statutory powers, 12568.
- Commercial, coal carbonised by, in 1902, 14210 (3).
- Crystal Palace, gas cooking stoves, number let on hire by, 12658.
- Gas Light and Coke:—
  - Business, no increase in during last ten years, 12629.
  - Carburetted water gas—
    - Production in 1901-2, 14210 (4).
    - Proportion to total quantity of gas made, 14210 (4), 14234.
  - Coal carbonised by, in 1902, 14210 (3).
  - Coke, weight sold per ton of coal carbonised, 14234.
  - Gas produced by, in 1901-2, 14210 (4).
- Metropolitan and Suburban Companies, coal consumed by, in 1881, 1891, 1901, 12627.

GAS COMPANIES—*cont.*
- Power production, some companies allow considerable discount to large consumers for, 12655.
- Provincial Corporations and Companies, Coal consumed by, in 1883, 1891, and 1901, 12628.
- South Metropolitan—
  - Coal carbonised by, in 1902, 14210 (3).
  - Gas produced by, in 1901-2, 14210 (4).
  - Coke, weight sold per ton of coal carbonised, 14234.
  - Extent of district served by, 12610.
  - Gas fires and cooking stoves, number lent on hire by, 12658.
  - Growth from 1840 to 1900, 12605.
  - Percentage of heat value of coal carbonised by, 11249.
  - Quantity of gas made compared with Gas Light and Coke Companies' production, 12613.

GAS COMPANIES and CORPORATIONS supplying gas in 1882 and 1901, 12599.

GAS-ENGINES—
- Anthracite coal, consumption per i.h.p. hour, using producer gas, 12864.
- Blast furnace gas—
  - Applied to, 9369 (10).
  - Consumption per h.p. compared with steam boilers and engines, 15597 (12).
  - Internal combustion engines using, Thwaite's system enables expansion of power capacity, 14500.
  - Scotland, used for power production, 15597 (12).
  - Thermal efficiency, 14500.
  - Use—
    - Direct in engines, economy of, 9369 (13).
    - Increasing in iron works, 14866.
- Blue water gas used in, 13027.
- Coal—
  - Consumption per h.p. hour in small, 14653.
  - Gas enriched with water gas requires larger consumption in engines than pure coal gas, 14367.
- Collieries, introduction into, difficulties of, 9344.
- Cost—
  - Compared to small steam plant, 10592.
  - Per h.p. hour of large engines with and without recovery of ammonia, 10495 (10), 10680.
- Dowson gas applied to, 9369 (10).
- Duff gas applied to, 9369 (11).
- Dynamos worked by, 12699.
  - Number of consumers using, in three principal London Gas Companies, 12697.
- Economy of, as heat motors, 9369 (9).
- Efficiency—
  - Increased field for attaining, 9369 (9).
  - To what due, 9369 (9).
- Electric Works driven by, 12877.
- Five hundred h.p. and upwards, number in use and in course of construction in Europe and America in 1902, 13069.
- Frodingham Iron and Steel Company, gas engine for Thwaite's purified blast furnace gas ordered by, 14627.
- Gas of various kinds, quantities required per b.h.p. 14369.
- Given amount of power, respective economy of steam and gas engines compared in obtaining, 14150.
- Heat from exhaust of, supplies steam to producers, 13185.
- Ignition of quick explosive gases, impossible to retard, 14568.
- Iron Works replacing steam engines by, 11898.
- Körting engines—
  - In use, March, 1903, h.p. represented by, 13176.
  - Number of cylinders, 10122.
- Large engines—
  - Difficulties with, 16543, 16577.
  - Economy—
    - In use compared with best type of steam engine, 10495 (10), 10626, 10675.
    - Resulting from replacing steam engines by, 13069, 13191.
  - Used in works with producer gas, coal consumption per h.p. hour, 14653.

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GAS-ENGINES—*cont.*
Largest single cylinder engine made, power and type of, 14536.
Life of, compared with steam engines, 13233.
Makers of large power capacity engines, 14505.
Mechanical efficiency compared with steam engines, 16398.
Midland Railway Company's contract with Westinghouse Company for generating electric and other power at Heysham by, 15653.
Mond gas applied to, 9369 (11).
Saving in—
Coal consumption compared with best modern steam engines, 12883.
Cost of erecting foundations for gas engine plant compared with steam plant, 13141.
In production of electric power compared with steam plant by use of, 13095, 13110, 13191.
Sheepbridge Iron Works, cost of plant exclusive of generators, 14710 (2).
Size of engines used with water gas, 13034.
Small engines—
Using town gas, estimated total h.p., 9369 (9).
Wastefulness compared with steam engines, 9413.
Small non-condensing steam-engines being replaced by, 12855, 14155, 14653.
Thermal efficiency—
Compared with steam engines, 16397, 16457, 16541.
Of blast furnace gas engines working on Thwaite's system practically automatic, 14502.
Thwaite's system practically independent of constant water supply, 14502.
Types used at certain iron works as blast engines and for driving dynamos, 11905.
Units of heat lost in, 12864.
Unsuitable for coal mines, 12916.
Water gas mixed with coal gas can be used in, 13025.
Weight of compared with steam engines, 13134.
Westinghouse 1500 b.h.p. engines to work with natural gas, 11298 (4).

GAS FIRES AND COOKING STOVES, Number of each rented from South Metropolitan Gas Company, 12658.

GAS LIGHT AND COKE COMPANY (*see* Gas Companies).

GAS MAINS—
Illuminating power of gas affected by sharp bends in, 14303.
Leakage from, 10668.
Tarry deposits in, cause variations in illuminating power of gas according to temperature of earth enclosing mains, 14286.
Trapped syphons needed for outlet of tar, 10569.

GAS OIL, special qualities of, 13478.

GASOLINE, employed in internal combustion motors, 13342 (3).

GAS PRODUCERS—
Advantages as regards saving of smoke and coal, 12864.
Area occupied by compared with steam plants, 13242.
Ash, quantity of in coal immaterial, so far as injury to plant is concerned, 12931.
Capital cost compared with steam plants, 9517.
Coal—
Class of, required, 12866, 13202.
Consumption per i.h.p. compared with steam engines, 14811.
Now considered worthless can be used in, 12936.
Cost of—
Plant per h.p. including gas engines, 9369 (25).
Water gas installation compared with coal gas installation, 13058.
Dowson Producers—
Defect in, 10497.
Small plants use only anthracite or coke, 9520.
Dynamos, result of working, compared with steam engines, 14810.
Economy of producer gas used in gas engines for production of electric power compared with steam power, 13192.
Gas coke, consumption per i.h.p., 14815.
Gas engines worked with producer gas, fuel consumption per i.h.p., 14710 (1*h*).

GAS PRODUCERS—*cont.*
Gas holder not needed, 13240.
Ideal producer, qualities of, 10495 (3).
Installation best position for, 9423, 10459 (6), 10503.
Mond Producers—
Coal—
Consumption per day, minimum necessary to secure greatest economy, 9409.
Of inferior quality and high percentage of ash usable in, 9472, 9545.
Cost of plant compared with best steam plant, 10641.
Improvement—
Enabling tar to be entirely taken out of gas, 12898.
Permitting use of bituminous coal in, 12869.
Installations, where situated, 9467, 11890.
Nottingham coal used by Messrs. Crossley Bros., Ltd., 12907.
Power produced by Mond and Duff producers, cost compared with that given by steam installations, conditions influencing, 9409.
Production, method adopted, 10495 (4).
Producers, mode of firing, 10547.
Steam, object of excessive use of, 12892.
Supply of gas easily regulated with trifling loss, 10539.
Time occupied in blowing up producer, 10540, 10544.
Plant—
For bituminous coal principle of working, 12922.
Smallest size, economical, 12920, 14710 (1*h*).
Saving, annual, compared with average steam installation, 9369 (25), 9444.
Units of heat lost in, 12864.
Water, economy in, compared with steam plant, 13193.
Working, ease of starting, 9593.

GAS WORKS, annual coal consumption, 9369 (2), 15597 (14).

GEOLOGICAL SURVEY DEPARTMENT, analyses of coals from South Wales Coalfield carried out by, 12354.

GERMANY—
Blast furnace gas, high efficiency of, 14455.
Briquettes—
Brown coal, manufactory near Bonn, 16913.
Process of manufacture, 16838.
Coal—
Coking coal exported to, 8807, 15715.
Inferior in size and quality to English, 8749, 10071.
Preparing for sale—
Method employed, 10715, 10736.
Sizes into which separated, 10071, 10150.
Two or more sizes mixed in certain proportions regularly supplied to customers, 10728.
Washed, percentage of, 10071, 10726.
Washing—
Largest size treated, 10071, 10147.
Plant—
Interstratification of seams with dirt renders use of indispensable, 10719.
Machinery used, 10149.
Coke broken into nuts and peas, 11153.
Depth of deepest mine, 10792.
Gas—
Making, percentage of heat value of coal used in, 11245.
Small producers extensively used, 13217.
Improved appliances at collieries, reason for adopting, 14984.
Iron and steel manufacturers far ahead of English in the matter of economies, 11907.
Large coal, proportion produced, 10715.
Monmouthshire coal used for coking, 10277.
New ideas adopted by manufacturers more quickly than in this country, 14619, 14648, 16558.
Oldenburg, peat charcoal manufactured at, 16921.
Peat—
Bogs, area and depth, method of determining, 16893.
Fuel used for power production, 16781.
Petroleum, centres of production, 13352 (28).
Price realised for certain quality of coal compared to English price for same quality, 10732.

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GERMANY—*cont.*
Westphalian Mines—
Disease among miners caused by high temperature, 10701.
Seams crushed by folding of strata, 10699.
Small coal, preponderance of, action of strata causing, 10700.
System of working practised, 10700.
Ventilation, 10706.

GLASGOW—
Electric lighting station—
Fuel costs per B.T.U., 16415.
Total works costs, 16415.
Electric power, costs compared with Leeds, 16424.
Tramway power house, cost of generating and distributing unit of electricity, 16421.

GOODRICH, MR. WALTER FRANCIS, A.I.M.E., London Manager for Messrs Meldrum, Manchester—
Evidence on economies in the use of coal; particularly as to improved appliances for the use of inferior classes of coal and refuse as fuel, 15151-15295.

GOODS TRAFFIC (*see* Railways).

GRATES—
Coal—
Consumption in ordinary grate per day compared with that in central heating installation, 16624.
Used in tests conducted by Coal Smoke Abatement Society, supplied to them by Government, 13313.
Florence grate, principle of, 13326.
Smoke-consuming—
Improvements in, impeded by ignorance, 13289.
Tests, mode of making, 13291.
Teale grate, principle of, 13324.
Ventilating Type—
Applicable to open fires with hollow backs, 16657.
Descending flue grates for central positions in large rooms, 16609 (2).
Details of comparative test of heating effect with iron grate with and without special back, 16609 (3), 16703.
Materials used in manufacture, 16609 (2).
Principle of, 16609 (2).
Temperature in room heated by, in relation to outside temperature, 16684.
Weather has but little effect on burning of, 13299.
(*see also* Coal Smoke).

GREAT EASTERN RAILWAY (see Railways).

GREAT WESTERN RAILWAY (see Railways).

GREENER, MR. THOMAS Y.—
Evidence on Economies in the preparation of coal for sale and use, 9184-9366.

GREENWICH—
Temperature—
At small depth compared with that of Edinburgh, 15575.
Of strata at three feet depth from surface, 15566 (8).

GRIENSTVEEN MOSS LITTER COMPANY (see Holland).

GRIMSBY, Dock accommodation inadequate, Great Central Railway Co. about to build new dock, 15346.

GYPSUM—
Formation of, 11496.
Mines on Weald of Sussex producing fine quality, 11268.

HADEN, MR. W. NELSON, M.I.H. and V.E., M.Am.I.H. and V.E.
Evidence on economies in the consumption of fuel for the heating of buildings by the introduction of central heating appliances, 16609-16764.

HALDANE, Dr., report concerning disease caused by high temperature in Dolcoath Mine, 10703.

HARTRIDGE, Mr., briquettes produced by, constituents of, 13342 (12), 13343.

HAULAGE—
Electrical winding engines used in South Russia, 10786.
Gas engine used for, 14962.

HEAT—
Chemical works study economy of, 9369 (15).
Industrial purposes, coal consumption for, 9369 (2).
Reducing, means of, 9430 (6).

HEATING—
Blocks of offices—
Central heating apparatus, advantages of, 16651.
Exhaust steam from engines generating electric current, used for heating offices, cooking, etc., 16651.
Buildings—
Air heated by exhaust steam, used for, 16465.
Open fires, results of heating by compared with central heating apparatus, 16646.
Gas as a substitute for coal for industrial and domestic purposes, economy of, 13124.
Private Houses, hot air system, description of houses to which suitable, 16740.
Public buildings and large institutions—
Central heating apparatus in conjunction with electric current generating plant, fitted with economiser and condenser, saving resulting from use, 16651.
Owen's College, Manchester, method adopted, 16699.
Schools, Combined system of hot air and hot water, method of distribution, 16691, 16732.
Westminster Abbey, method adopted, 16696.
(*see* Central Heating Installations.)

HELBING, MR. HENRY BERNARD, F.G.S.
Evidence on the solidification of petroleum, 14378-14465.

HICKMAN, SIR ALFRED, M.P.
Evidence on railway transport of coal, 11529, 11910.

HIGSON, MR. JOHN.
Evidence on waste in working, the limit of depth in mining, and economies in preparing coal for sale and use, 9784-9988.

HOLDEN, MR. JAMES, M.I.C.E., M.I.M.E., and Locomotive, Carriage, and Wagon Superintendent of the Great Eastern Railway.
Evidence on economies in the use of coal, particularly on the use of oil fuel on locomotives, 13761-14072.

HOLING—
Coal wasted by, 9784 (18).
Economical method of, 9784 (18).
South Wales Anthracite Coalfield, rarely needed, 15765.

HOLLAND—
Peat briquettes—
Griendstveen Moss Litter Company manufacturing, 16916, 16963.
Used for production of power, 16962.

HOPKINSON, DR. EDWARD.
Evidence on the use of gas engines for generating electricity, 13068, 13242.

HORSE POWER, total amount annually used in Great Britain, 9369 (4).

HOT AIR BLAST—
Advantages of, 12805 (1).
Very inferior fuel used with, 12850.

HOUSE REFUSE, destruction of in Meldrum furnace for steam raising, 15284.

HOWATSON WATER PURIFYING PROCESS, Cost of, 14745.

HUDSON, MR. JOHN G., M.I.C.E., M.I.M.E., Director and Chief Engineer of Messrs. Hick, Hargreaves & Co., Bolton.
Evidence on economies in the use of coal, particularly as to economy consequent on improvements in steam engines, 16232, 16390.

HULL—
Dock systems, local jealousies delay development of, 15336.
Docks served by different railway companies, 15339.

HUMIDIFIER, effect of using, 16730.

HUNGARY, petroleum production, 13352 (30).

HYDRO-CARBONS, disadvantage of latent heat in, 14489.

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HYDROGEN—
Control of pressure, sensitiveness of hydrogen fatal to, 14492.
Disadvantage of latent heat in, 14489.
Sensitiveness or rapid ignition of, 14507.

INCANDESCENT MANTLES—
Amount of light obtained, intensity of gas producing, 14271.
Bye-pass to burner, effect on mantles, 14373.
Candle power obtained per cubic foot of gas consumed compared with that obtained by flat flame burners, 14231.
Conditions producing light, 14266.
Economy in use of gas effected by introduction of, 14210 (1), 14211, 14229.
Effect on atmosphere of rooms, temperature, ceilings, books, etc., 14357.
Frequent renewal necessary, 14350.
Illuminating power of gas used does not affect light, 14210 (1), 14214.
(*see also* Welsbach Mantles).

INCLINATION OF COAL SEAMS, difficulties with coal-cutting machines in steep seams, 17112.

INDIA, Oil-bearing territory developed by Burmah Oil Co. and Assam Oil Co., 13350 (24), 13352 (35).

INDICATED HORSE POWER, term defined, 12864, 16392.

INFERIOR COAL—
Burning, means of, 9808, 9840.
Filling, price offered to men, 9847.
Used in conjunction with oil for steam raising, efficiency compared with best coal, 14032.

INFERIOR FUELS, Steam users condemn these as requiring special apparatus for burning, 15180.

INSPECTORS of Smoke not yet appointed by Local Authorities in many districts in London, 13246.

IRELAND—
Anthracite Coalfield, conditions delaying development, 15248.
Peat bogs—
Belfast, of good quality near, 16804.
Let at small royalty per ton, 16810.
Owners of, 16873.
Peat industry, Commission on, Report by Sir R. Kane, 16875.

IRON—
Ore—new sources of supply, 15595 (5), 15690.
Trade—
Castings, quality as good from open as closed top furnaces, 14863.
Coal consumption—
In iron and allied trades, in 1881 and 1900, 15597 (14).
In pig iron industry in 1881, 15595 (3).
Per ton of finished iron, 15595 (2).
Per ton of pig iron—
Best record for country as a whole and for a particular district, 15595 (3).
Reduction in, since 1873, 15595 (3).
Percentage proportion of total output, in 1881, 15595 (6).
Coal supplies, scarcity of cheap coal threatened in various centres of industry, 15594 (7).
Coke consumption per ton of iron, 15597 (11).
Fuel required to make a ton of billets from pig iron and to reduce the billets to rails, 15598*.
Output—
Great Britain in 1900, 14588.
Total annual output of finished iron in 1883 and in 1903, 15595 (2).
Pig iron—
Cost of labour at furnaces per ton, 15678.
Railway rates form large percentage of cost of, 11725, 11740.
Slag and heat lost in cooling may be utilised, 15598.
Siemen's regenerative furnace applied to puddling, 14896.

IRON—*cont.*
Works—
Blast furnace waste gases applicable to, in form of heat or power, 9369 (13).
Coke—
Beehive preferred, 9939.
Charged hot into blast furnaces, 9359.
Made at, 9287, 9350.
Coking plant erected at, instead of at colliery, reason for, 9357.
Condensing and electric plant, economy obtainable by introducing, 14906.
Sheepbridge, Gas engine plant generating electric power in use at, 14710 (2).
Surplus gases sold by, 9357.

IRON AND STEEL INDUSTRIES, coal consumed by, in 1871, 15595 (1).

IRONSTONE, Argillaceous or clay-band ironstone existing in United Kingdom, 15691.

ITALY, Petroleum production, 13352 (31).

IVANOVKA (*see* Russia).

JAPAN, Petroleum industry, centre of supply, 13350 (26).

JOSSE, Prof. E. (*see* Steam engines: Waste heat engines).

JEANS, MR. J. STEPHEN, Secretary of the British Iron Trade Association.
Evidence on economies in the use of coal in Iron and Steel manufacture, 15594–15730.

JUTE INDUSTRY, Indian, standard of economy of engines, how defined, 16353.

KEROSENE, lamp oil used in stationary engines, 13342 (4).

KIESELGUHR (Infusorial earth), Radiation prevented by covering pipes with, 14969.

KILOWATT, equivalent in horse power, 13070.

KIMMERIDGE CLAY—
Burnt as fuel in Dorsetshire, 11282.
Spontaneous ignition of natural gas from, 11388.

KIMMERIDGE SHALE—
Fuel gas, possible production from, for industrial purposes, 15147.
Oil distilled from, only suitable for fuel, 15078, 15085.
Products of distillation very inferior, 15078.
Sulphur contained to large amount in the Blackstone renders distillation offensive and destroys value of oil, 15078
Yield—
Estimated per acre, 13353 (46).
Of oil and sulphate of ammonia per ton, 13353 (46).
(*see also* Oil Shale).

KITCHENERS, Fuel consumption, average, in 4 feet wide closed range per day, 16627, 16629.

KIRBY, Mr. M. R., Result of tests with coking plant made by, 11211.

KITSON LIGHT—
Cost compared with—
Coal gas, 14355, 14364.
Electric light and coal gas, 14252.
Excellence and cheapness of, 12706.
Price per candle power per hour, 14247.
Process of production described, 14242.

KNOWLES, MR. JOHN, Mining Engineer and General Manager of the Pearson and Knowles Iron and Coal Company.
Evidence on economies in preparing coal for sale and use and on the use of coal, 9740–9783.

LANARKSHIRE COALFIELDS (*see* Coalfields).

LANCASHIRE & CHESHIRE COAL OWNERS' ASSOCIATION, Date of establishment, 12073.

LANCASHIRE AND YORKSHIRE RAILWAY (*see* Railways).

LARGE COAL—
Breakage of, methods for preventing, 9927.
South Wales Coalfield, Western Division—
Anthracite seams, proportion of large and small coal sent out, 15743, 16054.
Steam coal seams, proportion of large sent out, 15746.
(*see also* Coalfields and Germany.)

LEADBEATER, Mr., Solidified Petroleum produced by, 13342 (12).

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LEBOUR, Prof., Observation taken in Durham and Cumberland Collieries, showing ratio of increase in strata temperatures at certain depths, 15566 (11).

LEEDS, Electric Lighting Station—
Economical working, 16419.
Fuel—
Costs per B.T.U., 16403, 16418, 16565.
Price paid for, 16425.
Steam engines, types used, 16421.
Tramways, cost per unit of electricity delivered, 16421.
Works costs—
Compared with Northwich, 16407.
Per B.T.U., 16418.

LESSORS OF MINERALS—
Difficulties with—
Effect of, 9784 (10).
Overcoming, means suggested, 9784 (11).
Suggestions as to increasing size of holdings and length of leases, 8743 (77).

LEWES, Prof. VIVIAN BYAM, Professor of Chemistry at Royal Naval College, Greenwich, and Chief Superintending Gas Examiner to the Corporation of the City of London.
Evidence on economy in use of coal; particularly as to the manufacture of gas for the production of light, 14209–14377.

LIGHTING GAS (*see* Gas: Illuminating Gas).

LIGNITE—
Bohemian, used in lump form, 16994.
Cologne, obtained from open diggings, 16994.

LIMESTONE, conducting power of, compared with shale, 15566 (7).

LINSTY OR POST GIRDLES, shale in a state of transition, 9795.

LIVERPOOL DOCKS, High Level and Herculaneum deficient in capacity for dealing with coal traffic, 12097.
(*see* Docks.)

LIVESEY, Sir GEORGE, Chairman of the South Metropolitan Gas Company—
Evidence on economies in the use of coal; especially as to the manufacture of gas for lighting purposes, 12551–12755.

LOCOMOTIVES—
Boilers—
Anthracite injurious to, 13621.
Liquid fuel less injurious to, than coal, 13616.
Eight and six wheel locomotives, cost per engine mile compared, 13759.
Liquid fuel fire-boxes, method of adapting to coal, 13839.
Oil fuel, method of introduction into fire-box, 13697.
(*see* also Fuel.)

LONDON—
Coal consumption per annum, suggested method of calculation, 13308.
Gas consumed per annum, value of, 11350.

LONDON AND NORTH-WESTERN RAILWAY (*see* Railways).

LONGRIDGE, Mr. MICHAEL, M.I.C.E., M.I.M.E., M.A.—
Evidence on economies in consumption of coal consequent on improvements in engines and boilers during the past twenty-five years, 14652–14709.

LONGWALL (*see* Systems of Working).

LUBRICATING OIL—
Heavy Russian, specific gravity of, 13725.
Mineral oils, value for lubricating machinery compared with vegetable oils, 13598.
Pure, high flash point, mineral oil required for lubricating steam engines, 16389.

McLAREN, Mr. HENRY, M.I.Mech. E., of the firm of Messrs. J. & H. McLaren, of Leeds.
Evidence on economies in the use of coal; particularly as to possible economies in steam engines, 16391–16608.

McNAB, Mr. W., F.I.C.—
Evidence on peat fuel as a substitute for coal, 16765–17011.

MANAGERS' CERTIFICATES—
Available for the whole of the United Kingdom, 15801.
Examination for, form prescribed by Home Office, 15790.

MARYPORT AND CARLISLE RAILWAY (*see* Railways).

MAYFIELD, Sussex, experimental borings for natural gas made at, 11307.

MECHANICAL DRAUGHT—
Chimneys replaced by, 14965.
Systems described, 16391 (2E).

MECHANICAL STOKERS—
Advantages of, 16505.
Fine coal dust can be utilised with, 14752.
Greater evaporative power per lb. of fuel, 14972.
Smoke almost entirely consumed by using, 12797 (2), 14755.
Chain grate (Babcock and Wilcox) advantages of 14753.
Conditions under which economical, 16474.
Crampton process, 14989.
Disadvantages of, 14976.
Furnaces, admitting fresh air to, various methods described, 14753.
Incandescent furnace, air circulation described, 14757.
Schwartzkopff type—
Conditions militating against general adoption, 14765.
Method of working shown by drawing and note, 14920.
Principle of working, 14762.
Special features of, 14757.
Water evaporated per lb. of fine coal dust used, 14710 (1c).
Small coal stoked by, value for steam raising compared with large coal hand fired, 12814.
Underfeed type, principle of, 16510.
Various types of, 14753.

MELDRUM FURNACES (*see* Furnaces and Mr. Goodrich's evidence).

METHANE, Condition under which luminous, 11449.

MEXICO, Petroleum production, 13353 (56).

MIDLAND DISTRICT—
Coal all brought out of mines, 11070.
Mining leases, form of, 11068.

MIDLAND RAILWAY COMPANY (*see* Railways).

MILLER, Mr. GORDON WILLIAM, C.B., Director of Contracts for the Admiralty.
Evidence on economies in the use of coal and on possible substitutes for it in the Royal Navy. 12211–12550.

MINERAL LEASEHOLDS, (*see* Lessors of Minerals).

MINERAL OWNERS, Difficulties with, 9784 (28) (*see* Lessors).

MINERAL TRAFFIC (*see* Railways).

MINERS' WAGES—
Increase in—
Counteracted by employing up-to-date methods and appliances, 10995.
During past fifty years, 11164.
Payment—
Basis of, in Lancashire, 9976.
For large coal only, object of system, 10185.
On "through and through" or "run of mine" basis customary in small collieries in Monmouthshire, 10193.

MINES ACT, Present provisions as to depositing plans of abandoned mines inadequate, 15789.

MINES—
Coal consumption—
Annual, 9369 (2), 9373.
Saving possible by introduction of gas generators and engines, 9430 (5).
Coal mines, Capital invested, return upon during last fifteen years compared with previous fifteen, 11145.

MINES SURVEYORS, Suggestions as to a separate certificate for, 15809, 16120.

MINING LEASES—
Order of working seams, stipulations as to, 9784 (9).
Waste of coal occurring through absence of general provision for leaving barriers at stated intervals, 15765.

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MINING PLANS—
Abandoned workings, existing requirements concerning plans inadequate, 15752, 15789, 16115.
Accuracy would be assured if certified surveyors only were employed, 15928.
Check surveys, periodically made, 16140.
Inaccuracy of old plans, expense and loss of coal caused by, 15752, 16076.
Old workings, information concerning required, 15871.
Plans of abandoned mines—
Deposited at Home Office before 1896 very imperfect, 15878.
Should be available for investigation as soon as deposited, 15890, 16125.
Small collieries, often drawn by incompetent persons, 15862, 16121.
South Wales Coalfield, Western Division, Survey made by lessee's surveyor, 16138.
Suggestions as to certifying, 15752.

MITZAKIS, Mr. JOHN.
Evidence on the commercial value of solidified petroleum, 14482–14485.

MOND GAS (*see* Gas).

MONMOUTHSHIRE COALFIELD (*see* Coalfields).

MONT CENIS TUNNEL (*see* Tunnels).

MORGAN-BROWN, Mr., petroleum, solidification of, process patented by, 13342 (12).

Moss (Japanese, Chinese, and Corsican) petroleum solidified by means of an extract from, 13342 (12).

MOTOR CARS, Alcohol mixed with benzine used for, in France, 13566.

MOTOR LOAD FACTOR—
Economy of working dependent on uniformity of, 13075, 13081, 13095.
Percentages in various towns, 13075.
Tramways, average percentage of load factor, 13146.

MOTOR SPIRIT OR PETROL, Gasoline and Benzoline so called, 13342 (3).

NAPHTHA—
Engine worked by, largest, 13417.
Russian torpedo boat destroyer fitted with naphtha motor engine, 13342 (7), 13415.

NATURAL GASFIELDS OF ENGLAND, Limited—
Boreholes put down by, size of compared with American, 13315.
Borings at Netherfield, Ticehurst, Mayfield, Crowborough, and Wadhurst, 11307.
Capital of Company, 11308.
London, Brighton, and South Coast Railway, arrangement entered into with, concerning supply of natural gas to towns on the line, 11291.
Mineral rights acquired by in Sussex, 11300.

NATURAL GAS (*see* Gas).

NETHERFIELD, experimental borings for natural gas made at, 11307.

NEW BRUNSWICK, petroleum production, 13352 (37).

NEWFOUNDLAND, petroliferous territory, drilling operations in, 13352 (39).

NEWPORT, Coal exports, proportion of total production of Monmouthshire, 10214.

NEW ZEALAND—
Coal—
Resembles Welsh coal, 12293.
Tests of fresh wrought and stored, 12331.
Oil Shale—
Production in 1901, 13346 (19).
Seam at Orepoki, yield per ton, 13353 (44).

NITRATE FIELDS, Output diminishing, 10497.

NITRATE OF SODA—
Imports to Europe, annual, 9625.
Production, annual, 9075.

NITROGEN, Valueless as heat producer, 10514.

NON-COKING COAL—
Treatment by compression, 10095.
Utilising, mode of, 10155.
(*see* Coke).

NORTH EASTERN RAILWAY COMPANY (*see* Railways).

NORTHWICH ELECTRIC LIGHTING STATION—
Fuel costs per B.T.U., 16403, 16563.
Gas Engines, description of gas used, 16397.
Mond Company supply gas for power purposes, 16403.
Power, kilowatts used, 16433.
Works costs, 16405.

NOVA SCOTIA, shale beds, reported yield per ton, 13352 (38

NUTS, PEAS, ETC., approximate sizes of, 9956.

NUTS, bituminous, market value of, 9931.

OIL, Petroleum, purposes for which used, 13354 (70).
(*see* also Lubricating Oil).

OIL ENGINES—
Diesel type, mode of working, 13342 (5), 13461.
Heavy oil engines, manufacturers of, 13342 (4).
Marine purposes, oil engines may be used for, 9369 (8).
Priestman type, consumption of kerosene per b.h.p. hour, 13342 (6).

OIL FUELS—
Advantages of, 13346 (17), 13665, 13776, 13872, 13920.
Blast furnace oil used as, 12279, 13864.
Board of Trade Regulations prevent use of, on Great Eastern Railway Steamboats, 13922.
Borneo and Burmah produce, 12287.
Calorific value compared with coal, 13803.
Canada produces, 12284.
Carbonic oxide formed in burning compared with that from coal, 14004.
Caspian Sea steamers burn, absolutely without smoke, 13341 (11), 13499.
Cost compared with coal for driving locomotives, 13772.
Cost—
Compared with Russian anthracite in locomotive boilers, 13620, 13627.
Prohibits substitution for coal, 15080.
Deposits from vary greatly, 14044.
Economy, effected by use of, at electric power stations, 13602.
Furnaces—
Can be altered quickly and cheaply to burn, instead of coal, 13562.
Less injured by, than by coal, 13979.
General use of, conditions preventing, 15064.
Great Eastern Railway—
Amount annually consumed by eighty locomotives, 13935.
Brass foundry uses, 13887.
Cost per ton, 13941, 14064.
Countries using apparatus introduced by, for burning liquid fuel on locomotives, 13909.
Handling, cost compared with coal, 13942.
Locomotives driven by, number of, 13768, 13790.
Method of using, 13804.
Oil stores, precautions against fire, 13899.
Origin of use of, 13794, 13994.
High flash point required by the Royal Navy, 12312.
Inflammability of, experiments as to, 13882.
India, import duty on, reduction in, 13345 (15).
Locomotives—
Fired with, run small danger of fire in case of collision, 14019.
Method of introduction into fire box of, 13671, 13697.
Ostatki—
Briquette manufacture, used in, 13342 (12)
Consistency of, in winter and summer, 13709.
Cost compared with coal per engine mile in Russia, 13653.
Flash point, 13342 (13), 13857.
Liquifying in winter, method of, 13711.
Price—
At point of consumption in Russia compared with coal, 13648.
In 1887, 13652.
In North Russia compared with English coal, 13739.
Per ton in Russia in 1882, 1885, and 1887, 13627.
Residue after distillation of benzine and kerosene from petroleum, 13345 (13).
Saving compared with coal, 13684.
Specific gravity of, 13725.
Steam, method of getting up, on locomotives using, 13660.

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OIL FUELS—*cont.*

Petrol—
- Character of, circumstances tending to alter, 13358.
- Gasoline and benzoline so-called, 13342 (1).
- Specific gravity, 13342 (3).
  - Increased, reason for, 13358.
- Sumatra petrol, high freight charges keep back large available supply, 13530.
- Transport, methods of, 13355.

Petroleum—
- Advantages resulting from use of, 13342 (11), 13604.
- Baku oil-fields, definite fall in horizon year by year, 13405.
- Balakhany field (Russia), wells yield principally salt water, 13406.
- Borneo, export of crude, to United Kingdom in 1900, 13354 (70).
- Burner for use with liquid fuel, principle explained, 13346 (16).
- Californian oil—
  - Compared with Pennsylvanian, 13391.
  - Increased output, effect of, on manufactures, 13346 (20).
  - Maggots produced in, by decomposition, 13410.
  - Specific gravity, has highest, 13365.
- Countries in which found, 13346, 13350, 13353 (46).
- Crude oil, use as fuel general in oil-fields and where considerations of safety can be ignored, 13342 (14).
- Decomposition caused by exposure to sunlight, 13398.
- Distribution to retailers, mode of, 13354 (70).
- Efficiency compared with—
  - Coal, 13570.
  - Gas engines, 13572.
- Formation of, Mendeleef's theory referred to, 13399.
- Gypsum, theory connecting with, 11495.
- Internal combustion engines—
  - Motors, employed in, 13342 (1).
  - Worked with, in steam raising, economy resulting, 13518.
- Life of oil wells, average, 13558.
- Mayfield, Sussex, borehole at, yields good supply, 11282.
- Oilfields, heavier oil yielded by new than by old fields, 13363.
- Pennsylvanian crude oil, yield of bye-products per 100 gallons, 13346 (20).
- Price, decrease in, due to introduction of bulk system of transport, 13548.
- Profitable nature of industry demonstrated by experience of oil companies, 13550.
- Roumania, Export of, to United Kingdom in 1900, 13354 (70).
- Russian—
  - Crude oil, Russian Government and Baku refining firms oppose construction of pipe line for conveying oil to Black Sea, 13348.
  - Oil, high railway freights prevent export to Europe, 13347.
  - Wells, yield compared with American, 13346 (21).
- Solidification of—
  - Casein, used in, 13342 (12).
  - Chenhall method, 13342 (12).
  - Fish glue used in, 13342 (12).
  - Ingredients used in process, 13342 (12), 14379, 14421.
  - Leadbeater method, 13342 (12).
  - Stringfellow method, 13342 (12).
- Solidified petroleum—
  - Advantages of, 13488, 14379, 14383, 14399, 14401, 14413, 14429, 14467, 14482.
  - Amsterdam, manufactured in, 12275.
  - Calorific value compared with coal, 14404, 14467.
  - Can be burnt in same furnace grate and at the same time as coal, 14433, 14467, 14483.

OIL FUELS—*cont.*

Petroleum—*cont.*

Solidified petroleum—*cont.*
- Cost of production, 14406, 14427.
- Crude petroleum forms harder product than benzine or refined petroleum, 14425, 14441.
- Flash point raised by process of manufacture, 13494.
- Inflammability almost nil, 14423, 14467.
- Liquid form, can be restored to, 14418.
- Manufacture can be carried on when and in such quantities as are required, 14388.
- Proportion of petroleum contained in blocks, 14379.
- Space—
  - Occupied in storage, 14384.
  - Required for manufacture, 14463.
- Temperature does not affect product, 14450.

Spirit of petroleum—
- Evaporating agent in place of water, so used in motor launch engines, 13342 (9), 13422.
- Experiments with on "Zephyr" launch engine, 13423.
- Purposes for which used, 12557, 13354 (70).

Steam raising, methods of effecting combustion of oil used for, 13346 (16).

Transport—
- By pipes, cost compared with tanks. 13575.
- By tank steamers—
  - Discharging cargo of oil, method adopted, 13354 (70).
  - List of British and foreign owned steamers, 13353 (68).

United Kingdom, found in small quantities in, 13353 (46).

United States, exports of burning oil, proportions taken by Great Britain, Germany and the Netherlands, 13346 (20).

Use in furnaces, disadvantages compared with solidified petroleum, 14468.

World's—
- Consumption of, cubic space required to contain one year's supply, 13346 (18).
- Production in 1891, 13353 (67).

Power production compared with coal, 13758.

Price, conditions tending to reduce, 14067.

Relative value compared with coal, 12274.

Royal Navy—
- Complaints as to smoke caused by, 13498.
- Trial tests if successful will develop shale oil distilling industry, 12366.

Russia—
- Date of established use on locomotives, 13609.
- Factories and metallurgical works use, in place of coal, 13675.
- Locomotives driven by—
  - Number of, 13612.
  - Saving per engine mile by using ostatki in place of coal, 13684.
  - Storage and distribution to, method of, 13671.

Shale Oil—
- Gallons produced per ton of shale, 15123.
- Purposes for which used, 15068.
- Scotch shale works, annual production, 13346 (19), 15067.
- Steam raising, cost of, compared with coal, 15059.
- Value per ton of various products, 15070.
- Yield decreases with depth of seam, 15139.

Smokeless consumption, mode of, 13560, 13695.

Space occupied by, compared with coal, 13689.

Steamers—
- Convenience of, as regards storage, 13929.
- Saving effected by use compared with locomotives, 13953.

Storage—
- Cost of, compared with coal, 14050.
- Great Eastern Railway's method, 13879.

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OIL FUELS—*cont.*
- Supply, difficulties concerning regular, in large quantities at low price, 13874, 14027.
- Torpedo boats using, advantages compared with coal, 13930.
- Value of oils from various countries compared, 13542
- Various kinds of oil used cannot be mixed, 13799.

OIL GAS, Great Eastern Railway uses gas made from Solar oil for lighting railway carriages, 13990.

OIL GAS TAR, Railway Companies utilise in gas works and on locomotives, 13864.

OIL SHALES—
- Analyses of, by Geological Survey Department advocated, 12358.
- Australia (New South Wales) production in 1901 in statute tons, 13346 (19), 13353 (45).
- Bye-products obtainable from, 12362.
- Dorsetshire fields, financial difficulties in working, 12282.
- Kimmeridge Beds, reasons leading to neglect of working, 13476.
- Midlothian and Linlithgow, yield per ton, 13353 (46).
- New Zealand, production in 1901 in statute tons, 13346 (19).
- Practical tests of more value than analysis, 12359.
- Production in 1901, 13346 (19),
- Scotch fields, oil supplied to Royal Navy, 12273.
- United Kingdom, production in 1901 in statute tons, 13346 (19).
- Value decreases with depth, 13536.
- Yield of oil per ton of shale, 13469.

OLDENBURG (*see* Germany).

ORDER OF WORKING SEAMS—
- Immaterial if considerable distance between seams, 16148, 16185.
- Lower seams—
  - Advantages of working first, 16150.
  - If worked first render coal in upper seams hard to get, 9784 (7).
- Profitable seams worked first, 9784 (6), 16146.
- South Wales Coalfield, Western Division, working in ascending order impracticable, 15762.
- Upper part of seam worked after lower part, conditions rendering profitable, 11186.
- Upper seams if worked first give larger proportion of round coal, 9784. (8).

OSTATKI (*see* Oil Fuels).

OUTPUT—
- British coal, total output in 1871, 15595 (1).
- Cost of production—
  - Depth of working influences, 10976, 11009, 15484.
  - Increase from all causes during the past fifteen years, 11155.
  - Increase in during the last fifty years, 11168.
- Production per man, conditions influencing, 9784 (38).
- United Kingdom, annual, 9369 (2).
- (*see also* Coal and Coalfields).

OXFORD CLAY, used as fuel in Dorsetshire, 11519.

OXIDATION OF COAL, temperature influences, 14087.

OXYGEN—
- Compressed, should be at hand in producer gas works, 9533.
- Efficiency of furnaces increased by use of, 9459.

PAN BREEZE, Worst refuse from retorts, 15208.

PARAFFIN—
- Distilled from bituminous shale at Pounceford, Sussex, 1282.
- Scale and wax, annual imports from United States and Burmah, 13354 (70).

PARIS, air mains—
- Leakage, percentage per mile, 10495 (7), 10529.
- Pressure per square inch, 10495 (7).

PARUSCHOWITZ BORING, temperature of strata, ratio of increase compared with that of Schladebach and other places, 15566 (4).

PATENT FUEL (*see* Briquettes and Royal Navy and Appendix)

PEA NUTS, bituminous, market value of, 9931.

PEARSON, Mr. RICHARD, Managing Director of the Natural Gasfields of England, Ltd.
- Evidence on Natural Gas, 11264–11528.

PEAT—
- Absorbent property of, 16960.
- Briquettes—
  - Analysis of, 16933.
  - Calorific value compared with coal, 16812, 16866.
  - Canada, manufactory in Ontario, 16840.
  - Cost of manufacture compared with selling price, 16985.
  - Density compared with coal, 16817, 16865.
  - Domestic use, odour imperceptible when burnt in ordinary grate, 16977.
  - Evaporative power compared with Welsh coal, 16868.
  - Germany, peat fuel used for power production, 16781.
  - Ireland, used in, for power production in small industries, 16806.
  - Manufacture—
    - Processes of, 16786, 16840, 16903.
    - To be successful must be on large scale, 16881.
  - Oil compared with, 12277.
  - Power production by, at present experimental, 16776.
  - Russia—
    - Locomotives and factory engines fired with, 16782, 16902.
    - Manufactory at Ivanovka, 16973.
  - Scotland, manufactory at Dumfries, 16969.
  - Solidified petroleum mixed with, 16486.
  - Steamers, excellent for, being smokeless and compact, 16833.
  - Sweden, peat fuel used for power production, 16782.
- Bye-products of combustion trifling, 16831.
- Canada—
  - Drying, best time for, 16854.
  - Electrical digger employed, 16844, 16850.
- Charcoal made from, advantages of for metallurgical purposes, 16920.
- Coked in Sweden, 11239.
- Coking, Ziegler process, 16944.
- Cubic metre, weight of, 16930.
- Electrical drying, process described, 16923.
- Frost injurious to binding properties of, 16855.
- Mineral product, peat so considered in France and Germany, 16900.
- Moisture in, when cut, proportion of, 16788.
- Norway, peat fuel made in, 13487.
- Open air drying of, essential for commercially successful manufacture, 16783.
- Quality of, varies greatly, particularly as to amount of ash contained in, 16829.
- Sweden, peat fuel made in, 13487.
- Teller-ofen or Plate-drier, German apparatus for extracting moisture from, 16791.
- Water, extraction of, difficult, 16791, 16811.
- (*see also* Appendix).

PEAT BOGS—
- Area and depth, Russian method of determining, 16892.
- Considerable, in England and Scotland, 16769.
- Continuous growth of, 17000.
- Dartmoor, large area on, 16834.
- Depth of, necessary for commercial exploiting, 16964.
- Electrical generating stations on, driven by peat fuel, suggested, 16804.
- Germany—
  - Area and depth, method of determining, 16893.
  - Government owns, in North Germany, 16896.
- Ireland—
  - Area marked on Geological Survey maps, 16886.
  - Occupy position of former lakes, 17009.
- Isolated patches of little commercial value, 16954.
- Marl, accumulation of fresh-water shells found at bottom of peat bogs, 17010
- Maximum depth known, 16889.
- Moss litter for stable bedding, top of bog used for, 16829.
- Reclaiming ground by entire removal of peat growth only possible on dry moors, 17006.
- Scotland, Area marked on Geological Survey maps, 16885.

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PEAT BOGS—*cont.*
Sphagnum probable source of life, 17002.
Top of, not suitable for fuel, 16771.
Triangel, near Hanover, peat removed from large area which is now used as agricultural land, 17003.
PENNSYLVANIA, Natural gas, distance to which transmitted, 10643.
PERSIA—
Naphtha—
An article of commerce, 13353 (49).
Boring operations at Chiah Sourkh, 13353 (49).
PERU, petroleum production, 13352 (29).
PETROL ENGINES, consumption of spirit per b.h.p. hour, 13342 (6).
PETROLEUM (*see* Oil Fuels and Royal Navy).
PHILIPPINE ISLANDS, Petroleum production, 13353 (62).
PICKING BELTS, seams formerly considered unworkable now worked to a profit by using, 9935, 9949.
PILLARS—
Carmarthen Coalfield, recoverable when left against influx of water, 16215 (20).
Large, preferable with strong roof, 16058.
Loss of coal in, by deterioration through exposure to atmosphere, 15765, 16051.
Rubbish, packing with, cannot replace, 9784 (30).
Shaft or surface support, size of pillars governed by inclination, etc., of strata, 9784 (19), 15843.
Small, cause more loss of coal than large, 16159.
South Wales Coalfield, western division, size of, 15842.
PITCH—
Briquette manufacture, average percentage used in Cardiff and Swansea manufactories. 10452.
Exports of, 10450.
Price of—
Germany, 10051.
Rise in, 9989*, 10363.
Cause of, 10455.
Effect of, 10446.
PONTYPOOL, Monmouthshire, natural gas burning at 11339.
POST GIRDLES OR LINSTY, shale in a state of transition, 9795.
POWER—
Distribution of—
Difficulties connected with irregularity of demand, 10495 (7).
Load factor :—
Regular production and storage of electrical energy a mode of increasing, 10495 (7).
Variations of, increase cost of energy, 10495 (7).
Production :—
Coal consumption :—
Annual, 9369 (2, 3).
Average per h.p. in large, medium, and small installations, 9369 (4), 9374.
Small and large engineering works, consumption compared, 13127.
Economy resulting from conversion of coal into gas for use in gas engines, 12864, 12934.
Gas used for, limit of proportion of hydrogen contained in, 14645.
Ideal gas for, calorific value formerly considered necessary, 14500.
Natural gas, efficiency as producer of power compared to coal gas, 11295.
Potteries, oil fuel and water gas better suited for use in, than raw coal, 9369 (15).
Steam power, efficiency compared with internal combustion engine, 14588.
Transmission by 48 inch main, efficiencies obtainable at various pressures and velocities, table showing, 10495 (8).
PREPARING COAL FOR SALE—
Coal from seams interstratified with bands of dirt or stone, method of cleaning, 10741.
Cost, relative, of washing and hand-picking, 10851.
Engine slack, now sold at a loss might be made more valuable by washing and sorting, 10730.
Gelsenkirchen Colliery Company wash all coal together, without separation, 10849.
Picking belts, advantages of using, 9935, 9947.
PREPARING COAL FOR SALE—*cont.*
Separation into sizes before washing, 10884.
Washing, weight added by, 10737.
Wharncliffe-Silkstone Colliery, method adopted, 10714.
PRESS-TORE, Peat briquettes used on locomotives in Russia. 16902.
PRODUCER GAS (*see* Gas.)
PUMPING STATIONS, loss of coal in barriers against water might be avoided by central pumping stations, 9784 (24).
PYRITES, many minerals so called oxidize with more or less ease, 14119.
RADIATION OF HEAT, preventing, substances used for, 14958, 14969.
RAILWAYS—
America, mineral train loads on Baltimore and Ohio line, average weight and price per ton per mile, 11529 (4), 11665, 11762.
American methods applied to great trunk lines of this country, advantage probable, 15721.
Carriage of coal—
Consignments, average weight of, 11536 (4), 11653.
Cost—
Per ton per mile, 11593.
Per ton per mile in passenger and coal traffic compared, 11592.
Rates—
Arrangement concerning, between Hull and Barnsley Railway Company and Denaby and Cadeby Collieries, 15349, 15486.
Group rates—
Formerly in force in South Yorkshire, reason for discontinuing, 15482.
Limit of distance covered, 12182.
London and North Western Railway rate, effect on shipping trade of Garston, 12087.
High rates—
Cause of, 11589 (1), 11531.
Proposed remedy for, 11726, 11729, 11775.
Large loads, reduction for, suggested, 11529 (1), 11636.
Minimum load charge, 11656.
Monmouthshire coal field, 10219.
Same per ton for any quantity, 15510.
South Wales, examples of, 11935, 12060.
South Yorkshire coalfield—
Coal from collieries passes over several railway systems, 15364.
Fixed according to position of collieries, 15348.
In some cases depend on quantity carried, 15349.
To London, 15499.
Total cost of putting coal on board at Hull, 15361.
Traders sending large consignments should benefit by reduced, 11786.
Train load rate, abolition of, effect on Yorkshire trade, 15443, 15498.
Train load rates, advantages which would result from, 15441.
West Cumberland district, 11966.
Train loads, means suggested for increasing, 11845.
Coal consumption,—
Annual, 9369 (2), 15597 (14).
Reducing, electric traction replacing steam, alterations necessary for, 9430 (4).
Combination of companies, high charges for carriage of coal caused by, 11529 (1), 11531.
Competition in facilities for mineral traffic, cost to companies might be saved, 11580.
Economies effected by railway companies should be shared by large traders, 15619.
Electric traction, energy should be generated at stations at intervals along the line, not by long distance cables, 10573.
Goods traffic—
Train loads on four railways, 11529 (4), 11163, 11762,
Wagon loads, average weight, 11529 (4), 11647.

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RAILWAYS—*cont.*

Great Eastern—
Coal—
Annual consumption, 13765
Cost—
Inclusive per ton, 14060.
Stacking, handling, and depreciation by atmospheric influences, 13776.
Reserves, method of dealing with, 13780.
Coal tar and oil gas used as liquid fuel on locomotives, 14034.
Locomotives—
Miles run annually, 13764.
Owned by, 13763.
Using oil fuel, method of working, 13804, 13964.
Oil fuel—
Cost per ton, 13941.
Distribution to locomotives, mode of, 13958.
Number of locomotives driven by, 13768, 13790.
Proportion of, imported from abroad, 13873.
Royal and fast express trains invariably drawn by liquid fuel engines, 13790.
Varieties of oil used, flash points of, 13853.
Stourbridge fire-bricks used by, 13843.
Great Western, Traders supply own wagons for minerals, 11690.
Lancashire and Yorkshire, train loads, 11840
Locomotives, number and value of, owned by British Companies, 9430 (4).
London and North Western—
Cost per train mile, 11529 (2), 11349, 11742, 11803, 11861.
For charges exclusively passenger and goods, 11529 (2), 11552, 11749.
Goods traffic, Cost for half year ending December 1902, 11804.
Goods and mineral traffic, Receipts per train mile, 11529 (2), 11541.
Mineral traffic, cost per train mile, 11529 (2), 11553, 11683, 11758, 11807.
Passenger traffic—
Cost for half year ending December, 1902, 11804.
Receipts per train mile, 11529 (2), 11541.
Scotch Express, cost per train mile, 11529 (3).
Passenger and goods traffic, cost as compared with mineral traffic for half year ending December, 1902, 11804.
Wagons—
Mineral traffic wagons supplied by trader, 11542, 11687.
Repairs to, cost falling on goods traffic account, 11545.
Maryport and Carlisle Railway, 3-ton wagons still used, 11966.
Midland—
Leicester Station, electric light, cost of working. 12864.
Wagons—
Charges for use, 11940.
Company does not supply all, 11690.
Difficulties with traders as to unloading, 11697.
Forty-ton wagons, experimenting with, 11953.
Supply, for mineral traffic, 15554.
Mineral traffic—
Average train loads on four railways, 11529 (4), 11663, 11762.
Load of minerals and goods, difference between, 11560.
Most profitable branch, 15503.
Proportion of working cost borne by, 11867.
Various rates per ton per mile, 11592, 11826.
North Eastern—
Dispute with Hull & Barnsley Company about Alexandra Dock, 15545.
Mineral traffic—
Increase in, 15720.
System of charge for, 11873.
Motor Cars, consumption of petrol per b.h.p. hour, 13342 (6).

RAILWAYS—*cont.*

Wagons—
Forty-ton, 15517.
Self-emptying, 11683.
Train of, 11529(4), 11668.
Large, increased receipts per freight train mile due to adoption of, 15600(19), 15720.
Twenty-ton, 11947.
Journals, measurement of, 12010.
Wheel base, measurement of, 11957.
Twenty-five to thirty ton, number owned by, 15619, 15724.
Passenger traffic—
Conditions adding to cost per mile, 11576.
Economies possible, 11602, 11607.
London and North Western and Great Western lines, instances in which economy combined with greater facilities to the public might be effected, 11603.
London to Glasgow, passenger trains, daily number running, 11529 (3).
Tickets should be available by different lines serving the same place, 11529 (3), 11733.
Sidings—
Charge on wagons not unloaded in certain time, 11640, 11703.
Colliery and railway companies' sidings should be open at both ends, 11972.
Saving by Edgehill principle of using gravity, 11972.
Taff Vale railway, full mineral train load, weight of, 11914.
Wagons—
Coal traffic, branches to which larger wagons might be applied, 15603.
Collieries using many lines must have their own wagons, 11986.
Colliery owners not unanimous as to advantage of large wagons, 11529 (4), 11671.
Company should supply wagons, 11691, 11698, 11813.
Delay in return of, difficulties caused by, 12109, 12170, 15551.
Fifteen-ton wagons—
Alterations in shipping arrangements necessitated by use of, 15452.
Cost compared with 10-ton, 15357.
Difficulties of using for house coal traffic, 15453.
Length of, 15377.
Tare compared with 10-ton, 15380.
Forty-ton wagons useful in iron trade for point to point traffic, 11960.
Greater economy in altering 10-ton to 20 tons than in buying 40-ton wagons, 11953.
Hire of, cost per ton, 11940, 15359, 15429.
Hull Docks incapable of dealing with 20 or 30-ton wagons, 15344.
Large wagons—
Combined orders would facilitate use of, 11879.
Involve alterations in lifts, 12068.
Iron and steel trades favour adoption of, 15600 (19).
Larger wagons might be used, 12135.
Objections to, 11682.
Suitable for coke trade, 11719.
Traders using should benefit by saving in tare, 11879.
Unsuited to Lancashire traffic, 12124.
Maximum weight which can be put on four wheels, 12014.
Powell-Duffryn Colliery increasing size of, 11943.
Return of empties, financial importance of, 11975.
Size of—
Alteration must be effected slowly, 11952.
Alterations at iron works rendered necessary by increasing, 15607.
Altering 10-ton wagons to take 12 tons of coal, conditions affecting cost, 12003.
Difficulties respecting, 15374.
Effect on railway, port and colliery arrangements of increasing, 15558.

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RAILWAYS—*cont.*
Wagons—*cont.*
Size of—*cont.*
Most profitable, for trader, 15432.
Most suitable, for coal traffic, 15646.
Tendency of late years to increase, 15515.
South Wales Colliery owners supply own, 11918.
Ten and 15-ton—
Cubical capacity of, 15387.
Length and height of, 15390.
Ten-ton, percentage of tare to paying load compared with 15-ton, 15446.
Thirty to 40-ton, advantages of, 15374.
Thirty-ton, cost of, 12038, 13383.
Railway Companies put difficulties in the way of introducing, 11624.
Saving possible by substituting for present size, 11618.
Traders—
Ownership by, avoids delays, 11919, 11929, 11984.
Using—
Railway Companies' wagons, difficulties of, 12143.
Twenty-five-ton wagons should receive from Railway Companies part of saving effected by use of, 11529 (4), 11630, 15517.
Trust suggested, 11989, 12148, 12156, 15402.
Twenty-ton—
Extra cost compared with 15-ton, 15382.
Great Western and North Western, on 12-feet wheel base unsuited to South Wales Collieries, 11954.
Substituting for 9-ton, increase in paying load of mineral trade resulting from, 15602.
Twenty to 40-ton mineral, difficulties with, as to screens, turntables, weighing machines and sidings at collieries, 11529 (4), 11671.
Twenty-five and thirty ton, adopted by Bolckow, Vaughan & Co., 15614.
West Cumberland local lines still use 3-ton or "chaldron," 11965.

REDDITCH ELECTRIC LIGHTING STATION—
Coal, quality used, 16413, 16442.
Fuel costs per B.T.U., 16410.
Gas engines driving plant, description of gas used in, 16397.
Power, kilowatts used, 16441.
Total works costs, 16410.

REDWOOD, DR. BOVERTON, adviser on petroleum to the Home Office and consulting adviser on petroleum to the Corporation of the City of London.
Evidence on petroleum as a fuel substitute for coal, 13340–13607.

REFUSE DESTRUCTOR, Air heater produces complete combustion, 12797 (1).

REFUSE HEAPS, turning to valuable account, instances of, 15228, 15237.

RHODES, MR. FREDERICK PARKER, Chairman of the Dalton Main Collieries.
Evidence on economies in the transport of coal, 15296–15565.

RICHMOND, SIR WILLIAM, unconsumed carbon in London, weight of daily waste estimated by, 13263.

ROBERTS, MR. JOHN, A.M.I.C.E., F.G.S., Examiner for granting certificates of competency under the Mines Regulation Acts for the South Wales District—
Evidence on waste in working in the Anthracite Coalfield, South Wales, 15731–16039.

ROLLING MILLS, room for various economies in, 14710 (2).

ROUMANIA, Petroleum production, 13350 (25).

ROUND COAL (*see* LARGE COAL).

ROYAL NAVY—
Coal—
Consumption—
Amount used during 1893–4, 1898–9, and 1902–3, 12215.
Australian and New Zealand coal used in 1902–3, 12212.
Estimate for 1903–4, 12215, 12510.
Foreign stations, purchase of coal for, 12221.
North country coal, 12212.
Welsh coal, 12212.
Supply—
Cardiff, coal shipped at, is colliery screened, 12427.
Conditions governing selection of collieries, 12237, 12248, 12251,
Extending area of, 12244.
North country coal—
Coalfields included in term, 12247.
Experiments with, 12244.
Patent fuel—
Cost compared with Welsh coal, 12431.
Ingredients of, 12258, 12301.
Method of using, 12263.
Qualities of, 12261.
Reasons for using, 12324.
Specially manufactured, 12254.
Stowing in bunkers, mode of, 12472.
Requirements relating to, 12385, 12458.
Smokelessness the first consideration, 12238.
South Wales Coalfield practically the only reliable source of supply for warships, 12372.
Stock, older used first, 12539.
Stoking, coal must give little trouble in, 12458.
Stores at foreign stations, 12213.
Testing coal—
As to quantity of ash and smoke, method of, 12456, 12462.
From new source, procedure adopted, 12452.
Transport from colliery to ship, method of, 12519.
United States supply coal for, 12297.
Welsh coal—
Economy in use, 12252.
Minimum requirement as to heat and speed met by, 12424.
North country coal formerly mixed with, for use in ships' furnaces, 12247, 12439.
Number of collieries supplying, 12225.
Total output of collieries supplying coal to, 12227.
Coaling ships, systems adopted, 12409, 12546.
Colliers—
Hired by Government for transport of coal, 12520.
Part of cargo used for steam raising on short voyages, 12521.
Furnaces—
Considerations influencing type used, 12370.
Constructed to burn coal and oil together or separately, 12434, 12449.
Experimental alterations carried out to admit of burning different kinds of coal, 12378.
Oil fuel—
Anthracite coal in conjunction with, tests being made, 12246, 12367, 12373.
Best results are obtained from oil used by itself, 12434.
Countries supplying, 12272.
Economy effected by using, 12477.
High flash point essential, 12312.
Oil used, quality of, 12268, 12274.
Price paid per ton, 12312.
Warships—
Difficulties in coaling, 11978, 12534.
Same quality of coal must be used in peace and in war, 12390, 12528.

ROYALTIES—
South Wales Coalfield, Western Division—
Coal consumed in colliery, free from, 16067.
Payment made by the ton, 15764.
West Yorkshire Coalfield, mode of calculating, 9836.
Wigan Coalfield, mode of payment, 9815.

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RUBBISH—
Bothwell Castle Colliery, dirt filled with coal, men penalised for, 8815, 8876.
Dirt sent up with coal, quantity renders preparation of coal for sale costly, 8743 (78).
Transferring from one seam to another, method adopted in South Wales, 15850.

RUSSIA—
Coal—
Donetz Basin, increased output from, 13728.
Import duty on, 13753.
Fuel oil, flash point, form of instrument used in testing 13443.
Heating buildings, mode of, 16747.
Kerosene, pipe line from Baku to Black Sea for conveyance of, 13346 (21).
Locomotives—
Oil fuel, number driven by, 13612.
"Press-torf" or peat fuel, driven by, 16782. 16902.
Lubricating oil, shipments in 1900, 1901 and 1902, 13354 (70).
Navy—
Alcohol as motive power, consumption per h.p. hour, 13342 (3);
Torpedo boat destroyer fitted with naphtha motor engine 13342 (7), 13415.
Oil fuel—
Date of established use of, on locomotives, 13609.
Factories and metallurgical works use oil, in place of coal, 13675.
Furnaces can be quickly altered for use with coal. 13614, 13657, 13678.
Locomotives—
Driven by, number of, 13612.
Method of supplying to, 13671, 13747.
Ostatki, or refuse left after distillation, used as fuel on locomotives, 13618.
Saving per engine mile effected by using ostatki in place of coal, 13634, 13731.
Storage, mode of, 13671, 13747.
Peat—
Bogs—
Area and depth, method of determining, 16892.
Systematic surveys made by Department of Agriculture, 16878.
Briquettes manufactured at Ivanovka, near St. Petersburg, 16973.
Petroleum—
Employed instead of coal or peat in steam raising. 13342 (10).
Petroliferous strata, yield of petroleum per square mile, 13353 (66).
Production, centres of, 13346 (21).

SADLER, Col., S. A., M.P.—
Evidence on preparing coal for sale and use, 9632–9739.

ST. GOTHARD TUNNEL (*see* Tunnels.)

SANDSTONE, Natural gas and oil contained in interstitial spaces, 11431.

SAXONY, oil distilled from lignite, 13353 (55).

SCHLADEBACH BORING, temperature of strata, ratio of increase, 15566 (3).

SCOTLAND—
Briquettes—
Annual output, 8783.
Purpose for which sold, 8783.
Coal-washing machinery used, 8743 (17).
Collieries, surface arrangements thirty years ago, 8743 (6).
Handling of coal and general pit arrangements, improvements made latterly, 8743 (20).
Lanarkshire coalfield (*see* Coalfields).
Peat briquettes manufactured at Dumfries, 16969.
Screening, method of, thirty years ago, 8743 (8).
Small coal, former waste of, 8743 (13).
Stirlingshire Coalfield (*see* Coalfields.)
Thin seams, changes in quality of coal, 8791.

SCREENING—
Double screening—
Process described, 10229.
Proportion of small coal removed by process, 10234.

SCREENING—*cont.*
Improvements in, 8743 (15).
Modern—
Method of handling coal, effect of, 9624.
Pithead arrangements, 9917.
Price of screened coal at North of England ports 9636 (5).
Small coal, treating with improved screening and washing machinery, result of, 8911.
South Wales Coalfield, Western division, Anthracite, crushing and separating, method of, 15783.

SCREENS—
Picking belts, seams formerly considered unworkable now worked to a profit by using, 9935, 9949.
Round holes preferable to bars, 8891.
Newport, Alexandra docks, size of mesh, 10242.
South Wales Coalfield, Western division, size of mesh, 16054.
Yorkshire Coalfield, sizes of mesh producing different varieties of coal, 9922.

SEMET-SOLVAY COKING PLANT (*see* Coking plant)

SEPARATING COAL INTO VARIOUS SIZES, advantage of, 9965, 11187.

SERVIA, Shale beds, yield of oil per ton, 13353 (54).

SEYMOUR, Mr. THOMAS, Colliery Manager—
Evidence on waste in working in the anthracite coalfield, South Wales, 16214–16231.

SHAFT SINKING, Beaumont machine, details concerning, 10950, 10957, 10962.

SHALE—
Conducting power of, compared with coal, 15566 (7).
Glasshoughton—
Analysis of, 15221.
Method of burning in Lancashire boiler, enabling evaporation of 1,000 gallons of water per hour, 15225.
Paraffin distilled from shale mined at Pounceford, Sussex, 11282.
Paraffin and ammonia distilled from shale poor in oil yield, 15141.

SHAW, Mr. JOSEPH, Chairman of the Powell Duffryn Steam Coal Company, member of the Monmouthshire and South Wales Coal Owners' Association, and a member of the Mining Association of Great Britain.
Evidence on railway transport of coal, 11911–12070.

SHEEPBRIDGE IRON WORKS—
Gas purifying plant—
Cost per i.h.p. compared with steam plant of same size, 14885.
Method of working, 14883.

SHIPPING, foreign and coasting, approximate annual coal consumption, 15597 (14).

SHIPMENT OF COAL—
Loading in baskets from boats still practised in Lancashire, 12104, 12166.
Self-trimming ships facilitate, 11923.
(*see also* Coal, cargoes of.)

SIDINGS (*see* Railways).

SIEMEN'S GAS (*see* Gas).

SIEMEN'S REGENERATOR, Economy resulting from use of, 14898.

SILICATE COTTON, Process of manufacture, 14959.

SIMON-CARVÈS OVENS (*see* Coking Plant).

SLACK—
Collieries generally produce large quantities of unmarketable, 10495 (1).
Price in Leeds, delivered, 13116.
Prices realised in 1880 and 1903, 9944.
Size of coal included in, with reference to use in manufacture of producer gas, 9600.
Value increasing with improved methods of preparing for use, 9604.

SLURRY OR POND SETTLINGS—
Calorific value in B.T.U. compared with best Welsh coal, 15183, 15196.
North's Navigation collieries burn, 15181.
Price per ton, 15189.

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SMALL COAL—
Anthracite—
Separating into sizes, method of, 16054.
Would be sent out if market available for, 16215 (25)).
Carmarthen Coalfield—
Coal left in pits too dirty for use if recovered, 16215 (29), 16218.
Large heaps of unsaleable coal on surface, 16212.
Demand for, extension of electrical plant causing increase in, 10479.
Economy of converting into coke or briquettes at collieries instead of exporting, 10492.
Egyptian market for, 12057.
Explosives, character of small coal affected by high, 9018.
Falling off in quality, causes of, 8908 (1,2), 8909, 9015, 9053.
Hand-stoking produces bad results with, 12819.
Mechanical appliances enable use of inferior and, 15159.
Mond gas production a market for, 15829.
Monmouthshire Coalfield—
Foreign matter in coal, proportion increased, 10224.
Price in 1903, 10287.
Nuts and pea nuts, relative proportions obtained, from 100 tons of mixed nuts, 9930.
Railway rates operate against utilisation of inferior and, 15164.
Scientific treatment of, economy consequent on, 10244.
South Wales Coalfield, Western Division, tendency now to send out coal formerly gobbed, 15824.
Unwashed, market value of, 9933.
Use increasing, 15022.
For bunker purposes, 10204.
Value enhanced by manufacture of briquettes, 9398.
Welsh steam coal, calorific power compared with large coal, 12054, 12059.
(*See also* Germany, Monmouthshire and South Wales Coalfields).

SMALL PROPERTIES, Tribunal suggested for dealing with difficulties concerning, 15765, 16027.

SMOKE ABATEMENT (*see* Coal Smoke).

SMOKE ABATEMENT ACT, Clubs not within provisions of, 13322.

SMOKE—
Boilers work most economically with slight smoke, 9439.
Loss of heat by, experiments testing, 12797 (2), 12805 (2), 12806.
Smokeless burning of coal, rate of combustion influencing, 12465.
(*see also* Coal Smoke).

SOAP, Petroleum oil and spirit used in manufacture of, 13599.

SOLIDIFIED PETROLEUM (*see* Oil Fuels).

SOUTH METROPOLITAN GAS COMPANY (*see* Gas Companies).

SOUTH SHIELDS ELECTRIC LIGHTING STATION, cost compared with Newcastle, 16506, 16605.

SOUTH STAFFORDSHIRE MOND GAS CORPORATION—
Powers conferred on by Act of Parliament, 9418, 10603.
Pressure used at South Staffordshire Station, 10605.

SOUTH WALES—
Barry, Cardiff and Newport principal shipping ports for coal trade, 11913.
Barry, tons of coal per hour unloaded by tips, 11923.
Briquette manufactories separate from collieries, 10443.
Coking industry, bye-products not recovered, 10249, 10475.

SOUTH WALES COALFIELD (*see* Coalfields).

SPAIN, Petroleum production, 13353 (53).

SPONTANEOUS COMBUSTION—
Cause of, 14086, 14263.
Coal cargoes—
Precautions to prevent firing of coal, 14101.
Sydney, four ships burnt at, in consequence of, 14076.
Welsh coal cargoes, numerous cases of firing, 14107.
Depth of working influences firing of seams in mines, 9784 (45).
Error of theory that wet coal fires more easily than dry conclusively proved by experiments in Australia and France, 14089, 14095, 14100, 14260.
Firing of coal, presence of pyrites, effect of, 13949, 14116, 14261.
Moisture preventing, 14089, 14260.
Royal Commission on dangers to which ships carrying coal cargoes are liable, 14078.
Wet and damp coal, difference of danger from ignition between, 14264.

SPORTS CLUB, Conviction under Smoke Abatement Act contested by, 13322.

STABLE BEDDING, Peat used for this purpose not suitable for fuel, 16771.

STATISTICS CONCERNING USE OF COAL, mode of obtaining, 9653, 9690.
Should be brought under the notice of users of heat and power, 9369 (26), 9370.

STEAM—
Auxiliary machinery in power stations uses large percentage of total steam raised, 16561, 16567.
Collieries, great waste at, 14800.
Exhaust steam—
Conditions under which it cannot be used to advantage, 12760.
Loss of heat in, 16455.
Uses to which it can be applied, 16391 (2d).
Utilised for heating purposes in United States, 16256, 16391 (4).
Yorkshire College, Leeds, heated by, 16391 (2d). 16461.
Expansion, minimum pressure at which economical, 14740.
Plant, cost varying according to quality, 10641.
Power—
Birmingham, coal consumed at various works per i.h.p., 13121.
Saving with gas engines as compared with steam power, 13100, 13106, 13119, 13191.
Raising—
Briquettes for—
Mode of manufacture, 9824.
Of inferior coal to equal Welsh steam coal, possibility of manufacturing, 9391.
Coal used in, size, importance of, 9394.
Surplus gases from coke ovens utilised for, 9634 (6).
Water evaporated—
In oven heated boilers compared to that in hand fired boilers, 9251.
Per ton of coal carbonised, 9250.

STEAM COAL—
South Wales Coalfield, Western Division—
Conditions under which it can be won, 15738.
High quality coal, small area available, 15738.
South Yorkshire Coalfield, Markets for, 15320, 15328, 15345.
(*see also* Coalfields).

STEAM COOKING APPLIANCES, economy in fuel possible by adoption of, 16627.

STEAM ENGINES—
Best results conditions influencing, 16322.
Builders' crane engines, coal, quantity used per h.p., 16360.
Class of work required of engine must influence design, 16534.
Coal—
Consumption per i.h.p. hour by best type of, 10495 (10), 10626.
Percentage of total heat in, converted into b.h.p. by best class of, burning 1¼ lbs of coal per i.h.p. 16393, 16396.

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STEAM ENGINES—*cont.*

Colliery small engines, steam used per i.h.p. compared with electric power, 14710 (lg).
Compound engines—
Condenser used in conjunction with, economy of high pressures, 14771.
Economy in coal consumption resulting from use of, 16493.
Indian jute factories using, 16353.
Pressure at which use is economical, 14710 (ld).
Two stage engines replacing triple and quadruple expansion types, 16254, 16309, 16349, 16353.
Condensing engines—
Power—
Percentage—
Obtainable from coal consumed, 16391 (2a).
Of total heat of coal which should be converted into, 16391 (1).
Purposes for which employed at British and foreign collieries, 14730.
Conservatism of users in this country compared with the Colonies, 16553.
Corliss type, size most used, 16310.
Cost per h.p. hour with best type of, 10495 (10).
Cut off must be apportioned to pressure, 14741.
Economy possible, suggestions as to, 16391 (2), 16457.
Efficiency—
Compared with that of gas and oil engines, 13342 (6).
Compound and triple expansion engines compared, 16317, 16320, 16530.
General, throughout country, 16265.
Highest obtained by best engines, 16255.
Factories, improvements not easily introduced, 12758.
Fuel economy of condensing and non-condensing types compared, 16391 (2b).
Gas producers and engines, reduction in coal consumption consequent on replacement by, 9369 (12).
Heat losses—
Chimney gases, appliances designed to prevent loss from, 16391 (2e), 26469.
Good engines consume about 2 lbs coal per i.h.p., 16391 (1).
Generating electricity, loss in engines used for, 16391 (1) 16546
High pressure steam—
Chemical and soap works require, 12801.
Engines having slide valves require increased number of cylinders to deal with, 16357.
Steam users slow in adopting, 12797 (3).
Trip gear enables compound engines to deal with, 16357.
Valves not effected by, 16383.
Improvements in—
During last 25 years, 14655.
Effect on fuel consumption, 16302.
Indian jute factories use compound engines, 16353.
Locomotives engines—
Mechanical draught, how regulated, 16486.
Radiation from cylinders, loss caused by, 16366.
Temperature of steam, working at 175 lbs. pressure, 16365.
Marine use, gas engines not likely to supersede steam for, 16587.
Mechanical work, maximum amount of heat of the steam obtainable for, 9369 (5).
Mill engines, percentage of improvement effected in working, by adding superheater, 16346.
Modern, increased efficiency of, developments producing, 9369 (6).
Non-condensing engines—
Power—
Percentage obtainable from fuel consumed, 16391 (2a).
Percentage of total heat of coal which be converted into, 16391 (1).
Perfect engine, qualities of, 16238.
Power, percentage obtained from coal—
In continuous running, 16237.
Intermittent running, 16328.
Power stations, type of engine best suited for, 16529.
Pressure, increase during last 25 years, 14653.
Purpose for which power required must influence decision whether to employ gas or steam engines, 16572.
Rise in price of coal leads to use of economical engine, 16554.
Steam consumption per h.p. hour, decrease during last 25 years, 14653.
Thermal efficiency—
Compared with gas engines, 16397.
Under best conditions, 14500.
"The Thermal Efficiency of Steam Engines." Report of Committee of Institution of Civil Engineers, 16313.
Triple expansion engines—
Friction in, compared with compound engines, 16320.
High capital cost, 14772.
Pressure at which use is economical, 14710 (d).
Saving effected by, 12758.
Superseded in some cases by two stage compound type, 16254, 16309, 16349, 16353.
Waste heat engines—
Additional power obtained from, 16247.
Experiments with, at Berlin, 16247.
Josse, Prof., E., experiments by, 16247.
Waste in working, cause of, 16249, 16255, 16261.
Winding engines, non-condensing type, steam consumed per i.h.p. compared with condensing type, 14710 (1e).

STEAM TURBINES—
Economy—
Apparent in constant running, 14778.
Utilising exhaust steam for driving, 16391 (2c), 16448, 16451.
Efficiency at low loads not good, 13189.
Electric—
Current generation economically effected by, 14710 (1e).
Power stations using, 16593.
Mechanical principle of, 16450.
Newcastle District Electric Power Station fitted with Parsons, 16601.
Speed, revolutions per minute, 14789.
Westinghouse Company use Curtis, 16602.

STEAM USERS, British, lacking in scientific knowledge, 15170.

STEAMERS—
Coasting, Annual coal consumption, 9369 (2).
Frequent renewals give opportunity for introducing experiments in engineering department, 12758.
Great Eastern Railway's, Board of Trade regulations prevent use of oil fuel on, 13922.
Oil fuel can be used with water-tube boilers as well as with cylindrical ones, 13455.
Peat briquettes, advantages of, as fuel on, 16927.
Petroleum fuel, advantages of liquid character of, 13437.
Tramp steamers, type of engine most economical, 16561.
Triple expansion engines used on, 16318.

STEAVENSON, Mr. A. L., result of working coking plant by, 11210.

STEEL—
Bertrand Theil method of manufacture, economy compared with ordinary process, 15598 (16).
Casting, coal consumption per ton, 15597 (8).
Malleable iron, economy of superseding by, 15598.
Rails, coal consumption per ton, 15597 (11).
Siemen's mild—
Date of introduction, 12757.
Steam boilers made from, 12757.
Talbot method of manufacture, economy of, 15598 (16), 15703.
Total output in 1881 and in 1902, 15595 (2).

STEEL AND IRON WORKS—
Coal consumption—
Annual, 9369(2).
Per ton of ingots, 15595 (2), 15597 (11).
(*see also* Iron.)

STETTIN—
Peat—
Briquette manufactory at, 16709.
Cut under water, 17007.

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STOKING—
Inferior fuel, best method of burning, 16500.
Small coal gives better results than large, 16504.
(*see* Mechanical Stokers).

STRAW, briquettes made from, in conjunction with coal and solidified petroleum, 13342 (12),

STREET LIGHTING (*see* Welsbach mantles and Kitson Light).

STRINGER, MR. GEORGE EDWARD, of the firm of Messrs. Stringer & Jaggar, Ltd., Park Mill and Emley Moor Collieries, Yorkshire.
Evidence on the use of coal-cutting machines in thin seams, 17012–17249.

STRINGFELLOW, MR. J. H. W., Solidified petroleum made by, 13342 (12).

SUBSIDENCE—
No limit to depth at which it may occur, 15765, 15883.
Packing cannot replace coal in its natural state, 15813.

SUB-WEALDEN BORINGS—
Cost of, provided by subscriptions, 11407.
Outbursts and explosions of natural gas during progress of, 11267.

SULPHUR, Texas oil contains, 13980.

SUMATRA, petroleum produced, rich in volatile constituents, 13529.

SUPER-HEATED STEAM—
Economy of use in small engines, 9369 (7).
Increased efficiency obtained by use, 9369 (7) 9447.

SUPERHEATERS—
Applicable only to some engines, 16335.
Boilers with, evaporate less water than without, 12791 (3).
Difficulties with tubes in forced draught furnaces using fine fuel, 16292.
Dry steam given by, value of, 16336.
Efficiency of, 16331, 16348.
Engine power increased by, 9369 (7), 9447, 12794.
Feed water, smaller quantity required with, 16368.
Fixing in boilers, method of, 16285.
Independently fired heaters, disadvantages of, 16291.
Pressure not affected by, 16362.
Priming very rare, 16284.
Saving effected by, greatest with wasteful engines, 16342.
Temperature—
Difficulties resulting from high, obtained by, 16273.
Influenced by situation of, 16274.
Of steam obtained by, 16271.

SUPERHEATING—
Advantageous only with high-priced fuel, 14797.
Drawbacks to, 9369 (7).
Use of, conditions under which economical, 14710 (1f).

SURVEYORS—
Certificates of competency suggested, 15757, 15790, 16120.
General standard of examination desirable, to be carried out locally, 16039.

SUSSEX—
Boreholes for natural gas, distance apart, 11414.
Hastings bed forms cap over Kimmeridge Clay constituting natural gasholder, 11274, 11397.
Iron industry may be restored if supply of natural gas for production of power can be relied on, 11298 (3).
Kimmeridge Shale, thickness and depth of bed from surface, 11267.
Section, 11280, 11338.
Strata in which natural gas is found, 11389.
(*see also* Gas, Natural Gas.)

SWEDEN, peat fuel used for power production, 16782.

SYSTEMS of working—
Deep mines, 9784 (40).
Longwall—
Advantages of, 9784 (12) 16092.
Modified system, 9832.
Small coal, proportion produced by, 16161.
Yield of coal greater than by pillar and stall, 15765.
Pillar and Stall—
Economy of system, conditions influencing, 9784 (15).
Pillars—
Large, economy of, 9784 (16).
Small, left long standing, proportion of coal lost by crush, 9784 (13).
Small coal, proportion obtained from large and small pillars, 16051.
Shallow mines, longwall unsuited to, 9784 (15).

TABLES—
Anthracite, yearly output of, from 1888 to 1902 (South Wales Coalfield, Western Division) 15741.
Boilers—
Types of, in use in 1886 and 1903.
Aggregate grate area of various, 14653.
Proportion of different, used in different classes of trade in 1903, 14653.
Relative numbers of various, 14653.
Coal, getting by hand or machine, relative cost of, 10772.
Coke ovens, thermal comparison of different types, 11218.
Consumption—
Coal—
Gross and nett per i.h.p. of factory engines in, 1877, 12761.
Per i.h.p. at various works in 1877 and 1902, 12761, 12763, 12765.
Fuel, in three Board Schools, heated by different methods, 16651.
Fuels, analyses of certain inferior, 15221.
Grates, domestic open fire, tests on six in London, 13327.
Liquid fuels, calorific value of, 14040.
London and North Western Railway, cost of passenger and goods traffic for half year ending 31st December, 1902, 11804.
Petroleum—
Imports of (with sources of supply) into United Kingdom in 1900, 1901, 1902, 13354 (70).
Gas oil, 13354 (70).
Kerosene, 13354 (70).
Spirit, 13354 (70).
Tank steamers, List of British and foreign, 13353 (68).
Storage installations in United kingdom, list of principal, 13354. (70)
World's production of, in 1901, 13346 (18).
Pig-iron works with steel works attached in the United Kingdom. 15599.
Producer gas, transmission of, through four feet main, 10495 (8), 10682, 10687.
Rates and distances from South Yorkshire Coalfield to certain ports, 15416.
Royal Navy, particulars of coal purchased for, 12412.
South Wales Coalfield—
Anthracite, yearly output of from 1888 to 1902, 15741.
Section of seams in, mode of working and yield per foot per acre, 16080.
Temperature—
Deepest known observations of, 15593.
Depth at which 100° F., is found, and calculated to be found, 15593.
Mean of surface soil at stations near coalfields, 15593.
Wagons to carry ten and twenty tons of coal, comparative figures, 15393.

TAR—
Coal and oil gas, used by the Great Eastern Railway Company, as liquid fuel on locomotives, 14034.
Yield per ton of coal at gas works and in coke ovens, 9664.

TAR OIL—
Gas Works and recovery ovens, annual production, 15067.
Scotch blast furnaces, annual production, 15067.

TAR SANDS (see CANADA).

TECHNICAL EDUCATION—
Advantage of extending, 10465.
Cardiff and Bristol have Technical Mining schools, 10322.

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TELLER-OFEN OR PLATE-DRIER, German apparatus for extracting moisture from peat, 16791.

TEMPERATURE—
- Air temperature—
  - Compared with temperature of earth 50 ft. below surface, in British Isles, 15579.
  - Compressed air used in coal mines for driving machines reduces, 11200.
  - Increase of ratio in proportion to height above sea level, 15577.
- Deep borings, conclusions drawn from observations taken in, 15570.
- Earth's, Lord Kelvin's theory, conditions indicated by, 15566 (7).
- East Manchester Coalfield, slow increase of temperature of strata, reason for, 15587.
- Gradients, mode of ascertaining, 15568.
- Liverpool, ratio of increase in strata temperature slower than elsewhere, 15587.
- Mines—
  - Cooling, mode of, 9859, 9915.
  - Depends not on depth only, 9909, 9784, 9791.
- Mont Cenis tunnel, temperature of strata, ratio of increase, 15566 (2).
- St. Gothard tunnel, temperature of strata, ratio of increase, 15566 (2).
- Simplon tunnel, temperature of strata, ratio of increase, 15572.
- Strata temperature—15566, 15572.
  - Difference in, at the same depths in the West and East of England, 15585.
  - Inclination of seams affects ratio of increase, 15590.
  - Percolation of water affects, 15586.
- Taking, mode of, 9881.
- Underground, ratio of increase, erroneous statements concerning, 15566 (6).
  (*see also* Deep Mines).

TEXAS, Spindle Top Gushers, cessation of flow, effect on price of oil, 13346 (17).

THERMAL STORAGE, principle and advantages of, 16515.

THEW, Mr. WALTER H.—
- Evidence on solidification of petroleum, 14466, 14481.

THICK SEAMS, South Wales Coalfield, method of working, 15821, 16049.

THIN SEAMS—
- Black Bed Seam, thickness of, 9983.
- Coal-cutting machines, will permit working if of good quality, 17111.
- Colliers—
  - Used to thick seams will not work in, 9982.
  - Will not work in all, 9985.
- Minimum thickness profitably worked, 17167, 17241, 17243.
- Quality of coal compared with thick seams, 17248.

THRELFALL, Mr. RICHARD, F.R.S., of the firm of Messrs. Albright & Wilson, consulting electro-chemical engineer.
- Evidence on storage and transport of coal, 14073–14208.

THWAITE, Mr. BENJAMIN HOWARTH, A.M.I.C.E., F.C.S.—
- Evidence on the manufacture of blast furnace gas, 14486–14649.

THWAITE'S "STATIC" SYSTEM (*see* Gas, Blast Furnace Gas, and Gas Engines).

TICEHURST, Natural Gasfields of England, Ltd., making borings at, 11307.

TIMOR (Eastern Archipelago), Petroleum of good quality found near surface, 13353 (61).

TORPEDO BOATS, oil fuel, advantageously used on, 13931.

TRADE UNIONS, effect of, on cost of getting coal, 11142.

TRANSMISSION OF POWER, advantages of, electric power, compared with gas, 14204.
(*see also* Electric Power and Gas).

TRANSPORT OF COAL (*see* Railways, Carriage of coal).

TREDEGAR COLLIERY (*see* Collieries).

TRIBUNAL—
- Establishment of—
  - Advocated, 15765, 15773, 15781, 15903, 16033.
  - Objected to, 16230.
- Inspector of Mines or Home Office official should be attached to local Court, 15926.

TRIPING—
- Purposes for which used, 8743 (11).
- Scotch term signifying coal and dross filled into wagon unscreened, 8743 (11).

TULLAMORE, peat briquette manufactory at, 16798.

TUNNELS—
- Mont Cenis, temperature of strata, 15566 (2).
- St. Gothard, temperature of strata, 15566 (2).
- Simplon, temperature of strata, 15572.

TURBINES (*see* Steam Turbines).

TURKEY, Petroleum production, 13353 (48).

UNDER-SEA-WORKINGS—
- Depth at which safe, 15880.
- Penclawd District—
  - Depth from surface, 15934.
  - Method of working, 15942.
  - Thickness and inclination of seam, 15933.
- Seams cannot be entirely removed, 15881.

URQUHART, Mr. THOMAS, M.I.C.E.
- Evidence on economies in the use of coal; particularly in the use of oil fuel on locomotives, 13608–3760.

VALVES—
- High steam pressure, valves not affected by, 16383.
- Slide, methods of obviating effect on, of high temperature steam, 16377.

VENTILATION—
- Furnaces now rarely used for, in mines, 14710 (1), 14723, 15023.
- Improved methods render working of mines possible at greater depths than formerly, 11038.
- Plenum inlet system, advantages of, 16680.
- Seams cut by machines more easily ventilated than those cut by hand labour, 17099.
- Sheffield Police Court, state of atmosphere before and after installation of Plenum inlet system, 16683.

VOEUX, Dr. HAROLD DES—
- Evidence on smoke abatement and improvements in combustion of coal, 13243–13339.

WADHURST, Natural Gasfields of England, Ltd., making borings at, 11307.

WAGON TRUST—
- Establishment suggested, 11989, 12148, 12156
- Theoretically a good idea, but not considered practicable, 15402.
- (*see also* Railways)

WALKER, Mr. GEORGE BLAKE, Chairman of Wharncliffe-Silkstone Collieries—
- Evidence on preparing coal for sale by washing, 10695–10913.

WASHING COAL—
- Advantage of, 9369 (19), 10171.
  - Cleanliness, 9660.
  - Commercial value increased, 11055, 11066, 11187.
  - Saving in railway carriage caused by absence of rubbish, 8908 (9).
- Carmarthen Coalfield, cost of, 16226.
- Cost per ton, 8908 (10), 8916, 9130, 9740 (2), 10161, 10297, 10336, 10438, 10490.
- Difficulty concerning, 10168.
- Dirt washed from coal, percentage of coal remaining in, 9204.
- Germany—
  - Gives more attention to, than England, 9013.
  - Improvements in, principle of, 8743 (18.)
  - Westphalia, practice in, 9009.
- Inferior coal—
  - Cleansing, method of, 9634.
  - Improved by preliminary treatment, 9369 (16), 9389.
- Loss of coal in—
  - Conditions affecting, 15783.
  - Proportion of, 8860.

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WASHING COAL—*cont.*
Markets for washed coal, 9936.
Minimum size not needing treatment, 8908 (8).
Nuts and Peas, price raised by, 9740 (2).
Relative values of washed and unwashed coal, 9934, 11094.

WASHING PLANT—
Baird & Co.'s Collieries, in operation at, 8743 (23), 8930.
Bothwell Castle Collieries, substitution of German plant for English at, 8895.
Coppée washer—
Construction prevents coal coming away with dirt in process of washing, 9275.
Details concerning, 9184 (5), 9202.
Costliness necessitates large area of work, 8743 (77), 8751.
Drainage of fuel after washing, mode of, 8908 (6).
Felspar washer used in England, 8992.
France a large purchaser of English made plant, 11185.
German methods, excellence of, 8747.
Improvements in, enable seams to be worked to a profit and abandoned collieries opened up, 8743 (32).
Installing, cost of, 10073, 10160.
Introduction of, 9634 (2).
Large washeries, economy of, 9000, 10724.
Luhrig washery—
Method of working, 9740 (2).
System, Messrs. Campbell & Binnie make improved, 10167.
Monmouthshire Coalfield—
Percentage of Collieries using, 10270.
Types used, 10477.
Murton washer, method of working, 9740 (2).
Plants unconnected with collieries, coal brought to, 8994.
Points to be considered concerning, 8908 (4).
Principles of action on coal, 8743 (17).
Principle of construction, 9634 (1).
Robinson washer, details concerning, 9184 (5), 9271.
Second class collieries cannot profitably use, 16211.
Type—
Producing best results, 9184.
Required for very fine coal, 8908 (5), 8912.
Types, various, 8743 (17), 8915, 9125, 9929, 10837.

WASTE IN WORKING—
Barriers, (*see that title*).
Causes of, 9784 (32), 9857, 15789.
Coal left unworked, 9784 (21).
Conditions influencing proportion, 9784 (4), 9787.
Difficulties with miners cause, 9844, 16215 (18).
Knowledge of the principles of mining and better discipline in mines would lessen, 15789.
Lanarkshire coalfield, saving effected by washing plant, 8743 (32).
Low prices influence, 9842, 11082.
Nottinghamshire, South, culm coal left in pit, 11075.
Proportion in ordinary working of mines, 9784 (4), 9819.
Remedy suggested, 9841.
Roof coal left is not necessarily lost, 11131.
Small coal left in pits might be made saleable by washing, 9784 (31).
South Wales Coalfield, western division—
Anthracite coal, total quantity of small annually gobbed, 15994.
Coal might be saved by stowing with rubbish brought in, if price of coal were high enough to make it profitable, 16078.
Packing if more systematically done would enable more pillars to be recovered, 16180.
Shafts, pillars supporting partly recoverable, 15765.
Steam coal, small gobbed, 9621, 9721, 9775.
South Yorkshire Coalfield, coal of inferior quality, proportion gobbed, 9784 (17), 9801.
Washing coal, loss resulting, 9327, 15783.

WATER—
Archbutt-Deeley process most suitable for water containing sulphate of lime, 14749
Chemical purifiers used, cost per 1000 gallons, 14701 (lb.), 14748, 15032.
Condensing steam, cooling arrangements enable, to be used over again, 14735.
Purifying—
Different chemical constituents require different treatment, 14747
Ingredients used to remove temporary hardness, 14924.
Methods of, 14743, 14927.
Quantity required by steam and gas plants respectively, 13200.
Unpurified, causes overheating of plates and reduction in evaporative power, 1472.

WATER GAS (Blue) (*see* Gas).

WATER GAS (Carburetted) (*see* Gas)

WATER POWER—
Niagara—
Cost compared with steam power, 13168, 13221.
Price per h.p. per annum, 13165.
Use for generating electric current too costly in this country, 16588.

WAYLEAVES, lessors exacting, 9784 (28).

WEALD, area of, 11333.

WELSBACH MANTLES—
Annual number used, 12690.
Bunsen burners only suitable for use with, 12696.
Bye-pass causes deterioration of, 12683.
Candle power per foot of gas under ordinary and extra pressures, 12676.
Gas Companies—
Arrangement with Welsbach Company as to royalty on, 12728.
Undertake maintenance of mantles at a fixed charge, 12621, 12687, 12730.
Increase of light and decrease in price of gas resulting from use of, 12684, 12726.
Street lamps, life of mantle on, 12691.
Street lighting—
Cost of, for street lamps, 12693.
Cost greatly reduced by use of mantles, 12695.
(*see* Incandescent Mantles.)

WEST INDIES, TRINIDAD—
Coal found in, 12489.
Pitch lake, annual output from, 13353 (43).

WESTPHALIA, ankylostomiasis increased by watering mines, 10834.

WESTPHALIAN SYNDICATE, method as regards sale of coal, 10733.

WETTER-SOHLE, German term for return air-way in mines, 10708.

WHEELING, VIRGINIA, temperature of strata in well 4,500 feet deep, ratio of increase, 15566 (5).

WINDING ENGINES, connection to central condenser receiving exhausts from all engines at colliery, general abroad, 14730.
Rapidity and certainty of action the first consideration, 14735.
(*see also* Collieries.)

WORKING HOURS—
Coal face, actual time of working at, 9784 (37).
Lanarkshire coalfield, reduction of, 8743 (22), 8833.

WORKMEN, amalgamation of, wages maintained at high level in consequence of, 10993.

WORKMEN'S COMPENSATION ACT, cost to colliery, 10988.

YORKSHIRE COALFIELD (*see* Coalfields).

ZANTE, pitch spring, petroleum found near, 13353 (51).

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